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# SPECIFICATIONS

FOR

## TWO HORIZONTAL DIRECT-ACTING

# COMPOUND SCREW ENGINES

FOR

# U. S. S. NEWARK,

OF 4,000 TONS DISPLACEMENT,

## EACH ENGINE, WITH ITS AUXILIARIES, OF 4,250 I. H. P.

## UNDER FORCED DRAUGHT.

INCLUDING

BOILERS, SCREW PROPELLERS, AND ALL APPENDAGES AND APPURTENANCES COMPLETE, TOGETHER WITH A LIST OF TOOLS, INSTRUMENTS, AND DUPLICATE PIECES TO BE FURNISHED.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1886.

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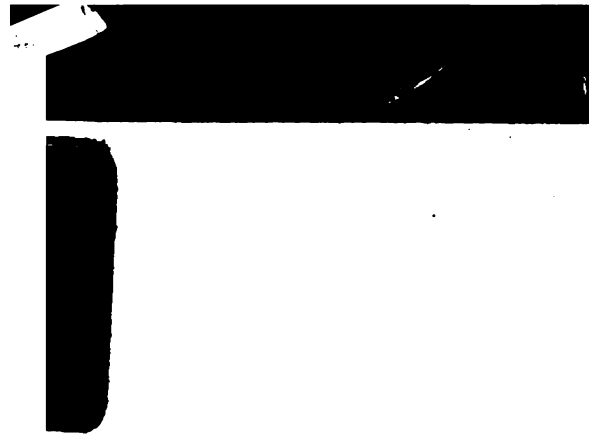

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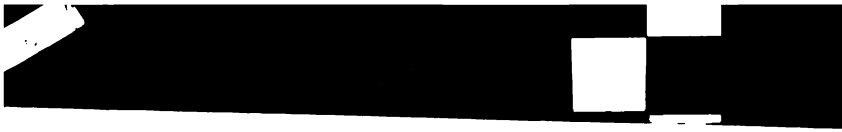


# SPECIFICATIONS

FOR

# TWO HORIZONTAL DIRECT-ACTING COMPOUND SCREW ENGINES

FOR A

# TWIN-SCREW VESSEL

OF 4,000 TONS DISPLACEMENT.

**Reference being had to the accompanying drawings forming part of these specifications.**

---

## GENERAL DESCRIPTION.

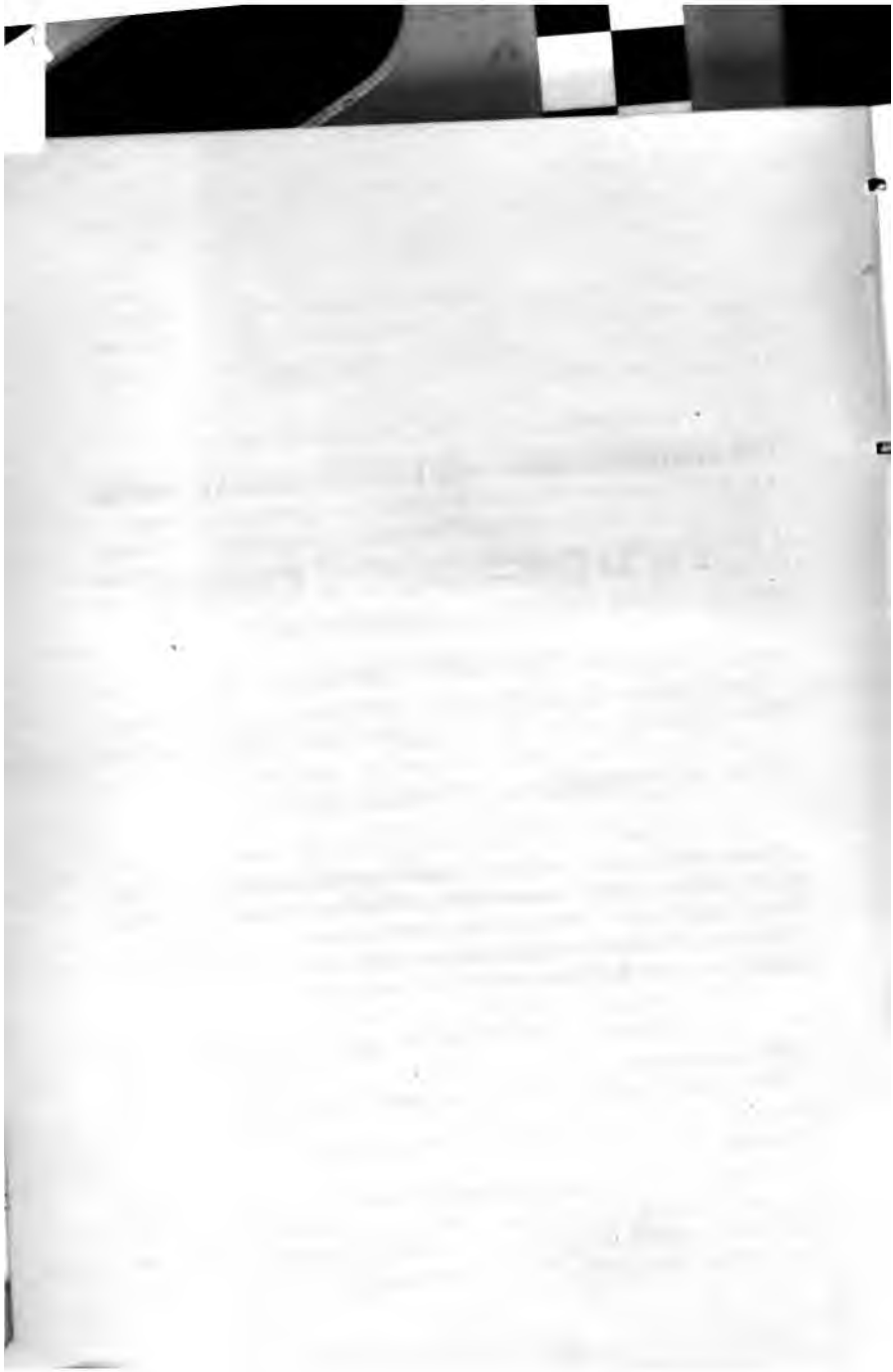
Each engine will have a high and a low-pressure cylinder of 46½ and 83½ inches diameter respectively, and a stroke of piston of 36 inches. The number of revolutions to be about 125 when developing 4,250 indicated horse-power.

The engines will be placed in separate water-tight compartments, and will be duplicates; the low-pressure being forward of the high-pressure cylinder in the forward and abaft it in the after compartment, the forward engine turning the starboard propeller.

The cylinders, with their covers and ends, will be jacketed.

### RECEIVER AND THROTTLE.

The receiver of each engine will consist of the passages and pipes connecting high-pressure and low-pressure valve-chests, and will be fitted with a safety-valve and a valve for admitting steam direct from the main steam-pipe.



The seat of the engine stop-valve, which will be used as a throttle, will be carried in the casing of each H. P. cylinder; the stem will lead to the working platform and be fitted with a suitable hand-wheel.

### MAIN STEAM-VALVES AND VALVE-GEAR.

The main steam-valves will be of the piston-type, one for each high-pressure and two for each low-pressure cylinder.

The valves will be actuated by radial valve-gear, as shown in the drawings, and arranged to cut off steam between the limits of .25 and .66 of the stroke in the high-pressure, and between .50 and .66 in the low-pressure cylinders.

### PISTONS AND RODS.

Each piston will have a single rod which will be secured to a cross-head moving in self-lubricating guides, bolted to lugs on the cylinder-casings at one end and supported by a column at the other.

### CRANK-SHAFTS.

Each crank-shaft will be a solid forging made of steel, in two interchangeable sections, and with the necessary coupling discs forged on. The two sections will be bolted together with their cranks at right angles; and counterbalances will be fitted to crank-throws for use if required.

### AIR-PUMPS.

The air-pumps, one for each engine, will be inclined and double-acting. Each will deliver into a feed-tank in engine-room, and be worked from a crank bolted to forward end of crank-shaft.

### CIRCULATING-PUMPS.

The circulating-pumps, one for each engine, will be of the centrifugal type, driven each by its engine direct; and so arranged as to be used for freeing the bilges in case of necessity.

### CRANK-SHAFT PILLOW-BLOCKS.

The castings containing the crank-shaft bearings will be cast in one piece for each engine. They will be bolted to engine keelsons and stayed to cylinders by steel tie-rods.

### HOT WELL OR FEED-TANK.

The air-pump of each engine will discharge into a feed-tank of boiler-iron placed directly over the air-pump delivery valves. Each tank will have a capacity of about 300 gallons and will be partitioned to act as a filter.

### CONDENSERS.

The shells of condensers will be cylindrical and built up of brass. The tubes will be of brass $\frac{5}{8}$ inch diameter, and each condenser will have a cooling surface of about 7,636 square feet, measured on the outside of the tubes.

The circulating-water will pass through one half the tubes and return through the remainder, thence overboard through the outboard delivery-valves.

The condensers will be located behind the engine cylinders, and will be supported on stanchions and otherwise well secured in the ship.

Additionally, the condenser in forward engine-room will be fitted with a straight-way stop-valve in exhaust and air-pump induction-pipes, for closing the communication between condenser and its exhaust-pipe and air-pump, when the condenser is used for auxiliary purposes.

### MAIN FEED-PUMPS.

There will be two vertical duplex pumps, located, one in the forward fire-room of after boiler compartment, and the other in after fire-room of forward boiler compartment, and both on the port side of the vessel. Their suction-pipes will connect to feed-tanks and forward condenser; and they will deliver water through check-valves on any of the boilers in either compartment.

### AUXILIARY FEED-PUMPS.

The main feed-pumps will be duplicated for the auxiliary feed system. One of these pumps will be located in the after fire-room of after boiler compartment, and the other in the forward fire-room of forward boiler compartment, and both on the port side of the vessel. They will be connected for drawing water from feed-tanks, boilers, sea, and bilges; and will discharge into fire main, overboard, and through boiler check-valves.

### DISTILLER AND PUMP.

The distilling-apparatus will be located in the engineer's work-shop on berth-deck, and will consist of one or more evaporators and distillers capable of furnishing 3,000 gallons of potable water in 24 hours. The pump for supplying the circulating water will have a capacity of a No. BB. Blake light service pump, and will draw its water from after fire-room sea-valve, and discharge through distillers and a valve on ship's side, forward.

### FEED-PUMP FOR EVAPORATORS.

There will be a steam-pump located in engineer's work-shop, on berth-deck, for feeding the evaporators. It will have a capacity equal to a Blake pressure-pump of No. Zero size, and will draw water from the sea and deliver through check-valves on the evaporators.

### TURNING-ENGINES, BILGE AND FIRE-PUMP.

There will be a pair of turning-engines for turning the shafting in port, located in the after engine-room, and working through a shaft and worm-gearing on suitable wheels on engine-shafts. Sliding clutches on the shaft of turning-engines will be fitted for disconnecting them from main shafting.

The cylinders of the turning-engines will be connected by yoke connections to water-cylinders below, which will be connected to draw from the bilge and sea, and discharge through fire-main and overboard.

PROPELLERS.

The propellers are to be of adjustable pitch, three-bladed, right and left-handed respectively, of about 15 feet diameter, and will be made of manganese bronze.

BOILERS.

There will be six horizontal tubular boilers of open hearth steel, with return-tubes above the furnaces, containing an aggregate grate surface of 690 square feet and a heating surface of 20,640 square feet.

Four of these will be double-ended and two single-ended. They will be located forward of the engines in two separate water-tight compartments.

Two double-ended and two single-ended boilers will be arranged in the after compartment, and two double-ended boilers in the forward compartment.

The fire-rooms will be four in number, arranged athwartships, two in each compartment.

The double-ended boilers will be 17.5 feet long, and the single-ended boilers 9¼ feet long. Each will have a diameter of 14 feet, and contain six and three furnaces respectively.

SMOKE-PIPES.

There will be two fixed smoke-pipes of oval cross-section, the tops of which will be at least 60 feet above the level of the upper grates.

The forward pipe will have an area of 39 square feet, and the after one 58½ square feet.

BLOWERS.

There will be eight blowers located, two in each fire-room, each driven by a pair of engines, and of the following capacities per minute:

After fire-room, after compartment, two of 13,000 feet each; forward fire-room, after compartment, two of 26,000

feet each; forward fire-room, forward compartment, two of 13,000 feet each; after fire-room, forward compartment, two of 13,000 feet each.

All blowers must be able to deliver the above quantities of air into the air-tight fire-rooms under a pressure of 4 inches of water.

## DETAILED DESCRIPTION OF ENGINES, SHAFTING, PROPELLERS, BOILERS, VALVES, PUMPS, &c.

### CYLINDER-CASINGS.

The cylinder-casings, which will include the steam and exhaust ports and passages, inboard heads, valve-chests, stop-valve seats, and sole-plates, are to be of cast-iron.

The casings for the high-pressure cylinders will be 52¾ inches diameter inside, and 1¼ inches thick. Those for the low-pressure cylinders will be 89¾ inches diameter inside, and 1¼ inches thick; and the metal in the steam-chests will be 1 inch thick. The casings will be fitted with linings of hard cast-iron; and an annular space of 1⅝ inches will be left for the jacket space between casing and liner.

### RECEIVERS.

The receivers will consist of the spaces between high-pressure and low-pressure piston-valves and their connecting pipes. There will be two copper pipes, of 17 inches internal diameter each, connecting each high-pressure exhaust-nozzle with the steam-chest of low-pressure cylinder. Each pipe will be fitted with a butterfly governor-valve and an expansion joint, as shown in drawings; will have faced composition flanges not less than 3 inches wide; and will be secured in place y wrought-iron bolts and nuts; through-bolts being used wh ere practicable.

A copper pipe of 4 inches diameter, with composition valve, will connect each receiver with main steam-pipe; the wheel on the valve to be operated from the working-platform.

A spring safety-valve with nickel seat, having an opening of 3 inches diameter and weighted to 40 pounds per square inch above the atmosphere, will be fitted to each receiver.

The cylinder-casings and covers after being placed in the ship are to be covered with non-conducting material, and neatly lagged with black walnut, removable where directed.

### SOLE-PLATES.

The cylinder-casings will rest upon legs having sole plates well-ribbed cast on them, and of the same length as the casings. They will be 21 and 12 inches wide for the high-pressure cylinders; 21 and 30 inches wide for the low-pressure cylinders; and faced $1\frac{3}{4}$ inches thick. The distance from axis of cylinders to face of sole-plates to be 50 inches; and the horizontal distance between axis of high-pressure and low-pressure cylinders will be 80 inches.

### CYLINDER-LININGS.

The cylinder-linings will be made of cast-iron as hard as tools can work. They will be $1\frac{1}{2}$ inches thick, and made with facings and flanges accurately fitted into and secured to the casings, as shown in the drawings. They are to be smoothly and accurately bored to a diameter of $46\frac{1}{2}$ inches for the high-pressure and $83\frac{1}{2}$ inches for the low-pressure cylinders; and of a suitable length for a stroke of 36 inches. The jacket spaces will be 35 inches long and $1\frac{5}{8}$ inches wide; and there will be packing spaces at the outboard ends 2 inches wide and 3 inches long.

The linings will be secured in place by bolts passing through the cylinder-heads, with nuts on the outside, the joint at inboard end of each cylinder being made tight by a copper-grommet under the flange. A copper-wire or grommet with follower and bolts will likewise be used for packing the expansion joints at the outboard ends of cylinder linings.

1¼ inches thick. The inboard-covers will contain the valve-stem stuffing-boxes, the bushings and glands being of composition. The packing spaces will be 1 inch wide and 7 inches deep; and fitted for either metallic or ordinary packing. Both inboard and outboard-covers will have projecting from their inner surfaces, suitable guides bushed with brass, for sustaining the weight of the valves. The covers will be secured in place by 1¼-inch bolts spaced not over 6 inches apart and with finished wrought-iron nuts. Suitable bosses will be cast on the upper surfaces of steam-chests, directly over each steam-port, for the attachment of approved oil cups.

### VALVE-SEATS.

Valve-seats or liners will be made of cast-steel of the toughest quality combined with a suitable degree of hardness. They are to be 1½ inches in thickness, and will be secured as shown in drawings, and accurately bored in place to a diameter of 19 and 27 inches for the high and low-pressure cylinders respectively.

### STEAM-PORTS.

The high-pressure cylinder steam-ports will be 3½ inches, and the low-pressure 4⅜ inches wide. There will be 12 diagonal, alternating right and left, bridges in each high-pressure, and 16 in each low-pressure valve seat. All bridges are to be ⅛ inch wide.

### MAIN STEAM PISTON-VALVES.

The piston-valves of the high-pressure cylinders will be made of cast-iron, the thickness of metal in the body of the valve being ½ inch, and the central connecting trunks having an internal diameter of not less than 13 inches.

The low-pressure piston-valves will be made of composition, ⅜ inch thick in the body of the valve; and the connecting trunks will have an internal diameter of not less than 16½

inches. The valves of both high and low-pressure cylinders will have cast at either end a central boss with radial arms, for the attachment of the valves to their stems.

Each end of all valves will be made steam-tight by two packing-rings of cast-iron, $1\frac{1}{2}$ x 1 inch in cross-section, cut obliquely and tongued, and held in place by a follower (of composition) and bolts (of wrought-iron). The distance pieces for separating the packing-rings at each end of the valves will be made of cast-iron for the high-pressure and of composition for the low-pressure valves.

### MAIN VALVE-STEMS.

The valve-stems will be made of cast steel, $2\frac{1}{2}$ inches diameter where they pass through the valves and 4 inches diameter in the stuffing-boxes. The thread on each stem, where it is secured to the valve, will be raised above the body of the rod; and the stem will be secured in place by a nut on each side of the cross-bar, the inner nut being of steel, and the outer one formed by a cast-iron sleeve 4 inches external diameter, which will be locked in place by a steel nut secured by a pin. This sleeve will travel in a composition bushing fitted in the inner projection of its outboard cover, and will be furnished with an approved lubricating device. Each valve-stem will be lightened by drilling a $2\frac{1}{2}$-inch hole axially, in that portion which has a diameter of 4 inches; this hole being tapped sufficiently deep for a steel bolt for connecting the valve-stem to its cross-head, to which it will be secured by two steel countersunk nuts with set screws.

### MAIN VALVE-STEM CROSS-HEADS.

The valve-stem cross-heads will be made of steel. Each will be bored to receive its valve-stem, and counter-board for the recessed valve-stem nuts.

The connections of cross-head to valve motion rock-shaft will be made by two links, as shown in the drawings, with conical ring bearings.

### THROTTLE AND STOP-VALVES.

The main steam-throttle for each high-pressure cylinder will consist of a disc valve, 15 inches diameter of opening, closing against the pressure in the steam-pipe; the seat will be carried in the cylinder casing, and the opening through the outside of casing will be closed by a finished cast-iron cover carrying the stuffing-box and gland.

The stem will project horizontally, and be fitted with a finished wrought-iron wheel arranged as shown in the drawings.

The valve-stem will be prevented from turning by a gib in the guide under the valve, which will fit a groove in the valve-stem.

### VALVE-GEAR.

The valve-gear is to be of the radial type, and to be so designed and constructed as to cut off steam between the limits of 0.25 and 0.66 of the stroke of the high-pressure pistons, and 0.50 and 0.66 of the stroke of the low-pressure pistons.

The cut-offs of the high-pressure and low-pressure cylinders are to be capable of being adjusted from the working-platform independently of each other.

The various functions of the valves must fall within the following limits, the fraction of the stroke being in all cases estimated from the beginning of the stroke:

HIGH-PRESSURE VALVE LIMITS.

| | Not Earlier Than— | Not Later Than— |
|---|---|---|
| | Stroke. | Stroke. |
| Minimum cut-off | 0.24 | 0.26 |
| Maximum cut-off | 0.66 | 0.68 |
| Exhaust opening at minimum cut-off | 0.77 | 0.80 |
| Exhaust opening at maximum cut-off | 0.91 | 0.93 |
| Exhaust closing at minimum cut-off | 0.64 | 0.66 |
| Exhaust closing at maximum cut-off | 0.85 | 0.87 |

LOW-PRESSURE VALVE LIMITS.

| | Not Earlier Than— | Not Later Than— |
|---|---|---|
| | Stroke. | Stroke. |
| Minimum cut-off | 0.49 | 0.50 |
| Maximum cut-off | 0.66 | 0.68 |
| Exhaust opening at minimum cut-off | 0.91 | 0.93 |
| Exhaust opening at maximum cut-off | 0.95 | 0.96 |
| Exhaust closing at minimum cut-off | 0.69 | 0.72 |
| Exhaust closing at maximum cut-off | 0.80 | 0.82 |

The angular positions of the crank-arm when steam is admitted must be the same in all gears of forward motion, and must not be farther than 10 degrees from the dead-center, nor nearer than 7 degrees.

The width of the port-opening for steam admission must be at least 3 inches at maximum cut-off, and $\frac{5}{8}$ inch at minimum cut-off for the high-pressure engine, and 3 inches and $1\frac{1}{2}$ inches respectively, for the low-pressure engine.

The distribution of steam in backward gear must be such as to permit the engines to be reversed quickly and to run astern at full power.

The eccentrics are to be forged from scrap-iron or mild steel. Each eccentric is to be made in two parts, securely fastened together by two mild steel bolts. They are to be truly bored to fit the shaft, and to be secured to the same by steel feather-keys and set screws of approved dimensions. They are to be truly turned to an eccentricity of $3\frac{1}{4}$ inches, and recessed at the sides to fit the flanges of the eccentric straps. Each eccentric is to be so keyed upon the shaft that when the crank of its engine is 8 degrees behind either dead-center, the line of eccentricity will be at right angles to a line joining the center of the shaft and the fixed center of the radius-arm of the valve-gear.

Each eccentric-strap is to be in two parts, of cast-steel, with brass bushings securely fitted and truly turned to fit the eccentrics. The two parts to be firmly fastened together by two bolts of mild steel with lock-nuts and keepers. The two parts of the strap to be separated by suitable brass chipping-pieces. A prolongation of one part of each eccentric-strap will form the eccentric lever, and will carry two mild steel pins.

Each of these pins to be surrounded by a hardened steel thimble, which is to be prevented from turning by suitable screw fastenings. One of these thimbles to form a journal to connect with the radius-link, and the other with the valve connecting-rod.

The movement of each valve is to be regulated by a radius-arm and a radius-link. Each radius-arm is to be carried in adjustable bearings rising from the corresponding crank-shaft bearing. A pin on the free end of this radius-arm will carry the radius-link. Each radius-link will be carried at an intermediate point by the pin at the free end of the radius-arm. One end of the radius-link will engage with the lower pin on the eccentric lever; the other end will be carried by a suspension-link connecting with the reversing-arm. The reversing-arm is to be carried in bearings above the radius-arm; and, at its back end, is to be formed into a sector with cut teeth engaging with a worm on the reversing-shaft. The reversing worm-shaft is to be carried in two bearings, the lower one being arranged as a thrust-bearing, with approved adjustments. The valve connecting-rods will engage at one end with the corresponding pins in the eccentric-levers, and at the other end with arms on the valve-motion rock-shafts. The valve connecting-rods to have such ends that the lengths between centers may be adjusted as desired. The valve-motion rock-shafts to be carried in bearings bolted to the cylinder casings. These rock-shafts are to have arms from which the motion will be communicated to the valve-stems by links.

The radius-links, suspension-links, valve connecting-rods, valve-motion rock-shafts, valve-links, reversing worm-shafts, and valve-stems to be forged of mild steel; finished all over.

All joint-pins to be of steel, hardened and ground to true circular, cylindrical surfaces.

All working bearings to be of phosphor bronze. The housings of the bearings carrying the radius-arms, reversing arms, and reversing worm-shafts; also the radius-arms and reversing arms, to be of cast-steel. The radius-links to be capable of adjustment so as to preserve a constant distance between the principal centers when taking up lost motion. Fixed trammels to be furnished, suitably protected from injury, for setting the radius-link centers to their proper distances; also for adjusting the position of the fixed center of the radius-arms.

The valve-stems are to be marked and furnished with fixed trammels for setting the valves without removing the valve-chest bonnets.

A spare set of phosphor bronze bearings to be furnished for all adjustable joints.

The arms on the valve-motion rock-shafts are to be as 2 to 3 in length between centers, the longer arms being those to which the valve-links are attached; the longer arms to be not less than 15 inches between centers.

Wipers carried by the upper ends of the eccentric levers are to furnish oil for lubricating the eccentrics, all moving connections with the eccentric-levers, and the connections of the radius-links with the radius-arms. These wipers to take oil from strips of webbing or other approved device, supplied by oil-cups suitably supported, and capable of adjustment so as to feed oil in all positions of the valve-gear, and also so as to independently adjust the supply of oil to the various parts.

All the working parts of valve-gear to have approved automatic oiling devices capable of supplying sufficient lubrication while the engines are in operation, without waste of oil, and with an oil capacity for at least four hours running.

All parts of the valve-gear to be suitably marked for convenience of putting together properly when overhauling. The valve-gear to conform to such drawings as shall be furnished.

REVERSING-GEAR.

Each engine will have an independent reversing gear, each of which will consist of a double upright inverted cylinder engine, driving by bevel-toothed gearing the reversing worm-shaft before mentioned.

The reversing-engines will be properly bolted to lugs forged on the forward and after tie-rods of the engine-frames.

The engines are to have cylinders of 5-inch bore, with 4-inch stroke of piston. The cylinders and valve-chests to be in one casting of composition. The pistons and valves to be of composition, with approved packing. The valve-stems and piston-rods to be of phosphor bronze. The cylinders to be carried on mild steel stanchions stepped in the reversing-engine bed-plate. These stanchions also carry the cross-head slides and the rock-shaft connected with the reversing-hand-lever. The engines to have piston-valves without lap or lead. Each valve to be worked by an eccentric set at right angles to the crank of its engine. The reversing of each reversing-engine to be effected by a piston-valve so constructed as to change the ports of the engine-valves from steam to exhaust, and *vice versa*. These valves to be worked by a differential screw-motion so constructed that the reversing-engines shall follow the motion of the reversing-lever. The reversing-lever to be conveniently situated on the working-platform, and to be fitted with a spring catch engaging in notches in a sector; these notches being plainly marked for the ahead and astern motions and for the various grades of expansion.

The reversing-lever sector to have stops to prevent the lever being thrown beyond the full ahead and astern positions. The reversing-levers to be connected by the necessary rods and bell-cranks to the differential screw-motion of the reversing-engines. Each reversing-engine to have a cylindrical throttle-valve so constructed that when steam is shut off from the engine the valve-chest shall be in connection with the atmosphere. Each of these throttle-valves to be worked by an independent lever at the working-platform; the levers to

have spring-catches to hold them in full open and shut positions. There will also be a stop-valve in the pipe taking steam to both reversing engines, with such gear that the valve may be opened and shut from the working-platform while handling the reversing-lever. The reversing-engines to exhaust into the feed-tank; the exhaust-pipes to have no valves or cocks in them which can prevent a free exhaust.

The shafts, connecting-rods, stanchions, pillow-block caps, all bolts, cross-heads and cross-head slides to be of mild steel. Bearings to be of phosphor bronze.

A shield of sheet brass of No. 16 B. W. G. will protect the back and ends of each reversing-engine from water spattered by the cranks. The cylinders and valve-chests to be neatly cast and left unlagged.

The reversing worm-shaft is to be squared at the top, and a suitable box-wrench furnished for reversing by hand. Suitable stops to be fitted to prevent the reversing-arm being thrown over so far as to endanger any part of the mechanism.

### STEAM-GOVERNOR.

There will be an efficient governor of an approved type, with all necessary connections, fitted to the governor-valves of each set of engines, for preventing racing in rough weather.

### CYLINDER RELIEF-VALVES.

There will be an automatic relief-valve, of not less than $5\frac{1}{2}$ inches diameter, located near the bottom at each end of each cylinder. These valves will be kept on their seats by spiral springs with approved method of adjustment. These springs to be long enough to allow the valves to open to their full extent without unduly increasing the load. The valves to be guided by loosely fitting wings.

The springs are to bear on shoulders on spindles which fit loosely in sockets recessed in the backs of the valves. These spindles to be so fitted that the valves can be moved by the application of a lever. The valves to be fitted with casings

which will prevent danger of people being scalded by hot water from the cylinders, and prevent steam and water reaching the valve-springs. Suitable fulcrums to be on casings, for the application of levers for working the valves. One lever to be furnished for each engine. A spare spring for each valve to be furnished. All springs to pass a satisfactory test.

CYLINDER DRAIN-COCKS.

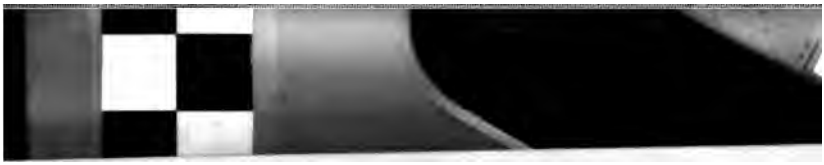
There will be fitted to each end of each cylinder, as low as possible, a drain-cock of approved design with 1¼ inch opening. These cocks to have bottoms cast in their shells and to have stuffing-boxes at large end. The shells to have set screws with conical points bearing against the bottoms of cocks to prevent setting fast. These cocks to be made of composition, and to be flanged, and bolted to bosses on cylinder casings or heads. The cocks on each cylinder to be operated by one lever at working platform. A pipe leading to bilge is to be attached to each cock by a union-joint with conical bearing.

MAIN-PISTONS.

The pistons will be made of composition with double shell well ribbed. The thickness of the metal to be ½ inch; that around the eyes of the piston rods to be 1½ inches thick. Each piston will have two cast-iron wearing-rings, 5½ inches wide, upon which it will rest, these rings to be so fitted that any part of the circumference can be adjusted to take the wear. The packing rings are to be ¾ inch thick and 3 inches wide, one for each piston, and will be adjusted by steel springs of proper tension. The followers are to be of composition 1¼ inches thick, and secured in place by 12 and 24 wrought-iron bolts 1¼ inches diameter for the high and low-pressure pistons respectively. All core-holes are to be in the periphery of pistons.

PISTON-RODS.

The piston-rods, one for each piston, will be made of steel finished 7½ inches in diameter, and fitted and secured to piston





by a composition countersunk nut locked in position. The rods will be screwed into the cross-heads and securely locked in place.

CYLINDER TIE-RODS.

The tie-rods securing the cylinders to pillow-block frames will be made of steel, turned to a diameter of 7½ inches, and each lightened by drilling a 4-inch hole axially through it. They will have T-heads forged on each end; and the forward and after tie-rod of each engine will have lugs forged on them for the attachment of the reversing-engines. These rods will be secured to the pillow-blocks, by the crank-shaft bearing cap-bolts; and to the cylinders, by steel bolts of the same size as the cap-bolts, tapped into nuts pocketed in the cylinder-casings.

PISTON-ROD STUFFING-BOXES.

The piston-rod stuffing-boxes will be formed in the cylinder-heads, and will be fitted with composition bushings and glands. The packing-space will be 1⅜ inches wide and 12 inches deep, and will be fitted for an approved metallic packing.

CROSS-HEADS.

The cross-heads are to be made of steel, finished all over, and fitted with composition-slippers 24 inches wide, 30 inches long, and ½ an inch thick, each secured in place by a flange and four wrought-iron bolts, as shown in drawing. The brasses for cross-head end of the connecting rods will be fitted into cross-head, and will be 1½ inches thick, faced 12 inches long, and bored to a diameter of 9 inches. They will be clamped by a steel-cap secured by steel bolts 3¾ inches in diameter, fitted with locked nuts.

CROSS-HEAD SLIDES.

The cross-head slides or guides will be made of hard cast-iron, with an oil-gutter at each end. They will have compo-

sition backing-guides 6 inches wide, each secured by 4 wrought-iron bolts 1½ inches diameter. The slides will be well secured to the cylinders at one end, and supported and fixed at the other end on a column which will rest upon a keelson and be substantially fixed to it.

### CONNECTING-RODS.

The connecting-rods are to be made of steel, finished all over. They will be 72 inches long between centers, 7½ inches diameter at cross-head end, and turned 10¾ inches at crank-pin end, which diameter will be reduced horizontally to 7½ inches by planing. Each rod will be divided at its cross-head end, and have a pin 12 inches long and 9 inches diameter worked from the solid forging for the cross-head journal. This pin will have a hole drilled axially from end to end, 1 inch diameter. The caps for the crank-pin brasses will be made of steel, and will each be secured by two steel bolts 4¾ inches diameter fitted with steel collar nuts recessed into caps and secured by steel retaining screws. The end of each bolt where projecting through the nut to be reduced to the diameter at bottom of threads; finished hemispherically, and fitted with a split-pin.

The brasses for crank-pins are to be 2 inches thick, and accurately fitted to pins and rods.

### CRANK-SHAFTS.

The crank-shaft for each set of engines will be made of steel, forged with solid webs and couplings, and in two interchangeable sections, each 7 feet 7½ inches long, which will be bolted together with their cranks at right angles.

The shaft-journals will be 13 inches diameter; the central journals 16 inches long, each; and the forward and after journals each 22 inches long. The crank-shaft webs will be 8 inches thick; the crank-pins 13 inches diameter and 20 inches long; and the couplings 3 and 3½ inches thick and 26 inches diameter. The crank-pins and shaft-journals will have 4-inch

holes drilled axially through them; and the crank-pins will have radial holes extending to the surface of the pins, as shown in the drawings.

All journals when finished will be tested and their accuracy proved.

A crank having a throw of 18 inches will be bolted to the flange on forward section of each shaft, for working the air-pump.

### CRANK-SHAFT AND CRANK-PIN BRASSES.

These brasses will be made in two parts, 2 inches in thickness, and bored 13 inches diameter. They will be faced to allow of ample end motion and to match the adjoining webs or eccentrics. The shaft-brasses will be bored in place; and will have a hole 2 inches in diameter in the center of each cap-brass through which the journal can be seen. Both shaft and crank-pin brasses will be scraped to accurately fit their journals.

### BED-PLATES AND PILLOW-BLOCKS.

The bed-plates for pillow-blocks will each be made of cast-iron in one casting, or in duplicate parts divided at the center of its length, as may be determined. The bed-plate will carry the pedestals for crank-shaft bearings (four in number) for each set of engines. The bed-plates and pedestals will be cast hollow with walls 1 inch thick, the metal around the brasses not to be less than 3 inches thick. The bottom of bed-plates where they rest upon the keelsons will be faced $1\frac{3}{4}$ inches thick, and $6\frac{1}{2}$ inches wide, and will be well ribbed to the walls of the bed-plate. The jaws of the bearings will be covered by finished cast-steel caps with a hand-hole in each. They will conform in width to the jaws and be secured to them, in each case, by two steel bolts, $3\frac{3}{4}$ inches diameter, which will also serve as retaining bolts for cylinder tie-rods. These bolts will be fitted with finished steel nuts secured by steel set-screws.

SURFACE-CONDENSERS.

The surface-condenser of each engine will be cylindrical in form; built up of sheet brass $\frac{1}{4}$ of an inch in thickness and amply stiffened by angle and T-rings, and with composition flanges for the tube plates.

The exhaust and discharge-nozzles and chambers for the circulating-water, with their covers, are to be made of composition as thin and light as is compatible with ample strength and stiffness. The diameter of the two exhaust-openings and of the discharge-opening to air-pump will be respectively 20 and 12 inches. The injection and delivery-openings for circulating water will be 15 inches in diameter. All flanges to be not less than 3 inches wide. An internal pipe of brass, perforated for spraying the water, is to be fitted in each condenser for use as a salt-water feed; the pipe to be 3 inches in diameter and to have a composition stop-valve attached connecting it to the circulating side of the condenser.

Each condenser will contain 3,500 seamless, drawn, brass tubes $\frac{5}{8}$ of an inch outside diameter, and of No. 20 B. W. G. in thickness, spaced $\frac{5}{16}$ of an inch between centers. The exposed condensing length of the tubes will be 13 feet 4 inches, giving a total cooling surface of 7,636 square feet.

The tubes in each condenser will be arranged in two divisions; the condensing water passing through one and returning through the other division to the outboard delivery-valve. The tubes will be thoroughly tinned inside and out previous to the last drawing.

The tube-plates will be of brass $1\frac{1}{8}$ inches thick; bored or cored for the tubes, and counter-bored $\frac{13}{16}$ of an inch diameter and $\frac{3}{4}$ of an inch deep; the packing to be compressed by composition glands screwed into the tube-plates and having a device for preventing the tubes from crawling.

The tubes will be suitably supported by an approved system of composition diaphragm and deflecting plates in each condenser.

Additionally, the condenser in the forward compartment

will be fitted with straightway-valves in its cylinder exhaust-pipes and discharge-pipe close to air-pump, for closing all communication with the main engine when the condenser is used for auxiliary purposes; the openings of these valves to be equal to the area of their respective pipes.

The diaphragm in the circulating water-chamber of each condenser will be fitted with a rectangular hinged valve of composition, having an opening of 16 by 20 inches for allowing the water from the circulating-pump to pass overboard directly when that pump is used for bilge purposes. This valve will be operated by a lever for closing and securing it, when it is desirable that water should pass through the tubes of the condenser.

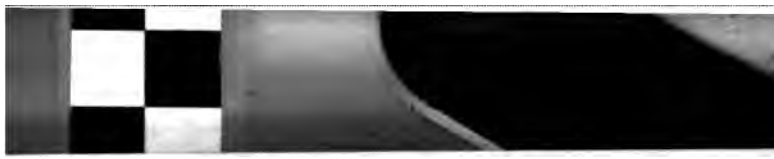
### EXHAUST-PIPES.

The exhaust-pipes, two in number, connecting each low-pressure cylinder with condenser will be 20 inches internal diameter each, and made of copper; they will be fitted with expansion joints, and with composition flanges, faced 3 inches wide, riveted and brazed. The opening in bottom of condenser for the discharge of water and vapor, will be connected to the induction side of air-pump by a copper-pipe of 12 inches internal diameter with composition flanges, faced 3 inches wide, riveted and brazed.

The auxiliary exhaust-main, where it passes through the engine compartments, will have a diameter of 8 inches, and will be made of copper. It will have in each engine compartment two exhaust connections; one to the condenser and another to the engine-receiver, with suitable stop-valves for closing the connections at will. All flanges will be made of composition, faced not less than 3 inches wide, riveted and brazed.

### AIR-PUMPS.

Each engine will have an inclined, double-acting air-pump 21 inches diameter and 36 inches stroke, which will be operated by a crank bolted to forward section of crank-shaft.





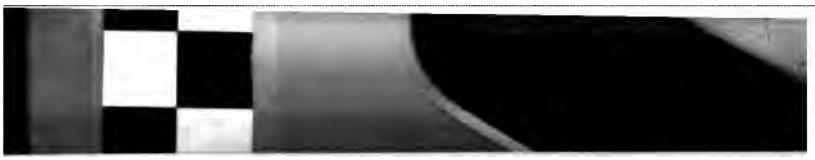
The pump-cylinders, valve-chests, covers, bonnets, and valve-seats will be made of composition. The cylinders will be 1¼ inches thick, and of sufficient length for a stroke of 36 inches. The valve-chests will contain, at each end of the pump, valve-seats, properly faced, with 18 induction and 16 delivery-valves of 5½ inches diameter of opening, arranged as shown in the drawings. The valves are to be made of hard rubber, and will be fitted with brass guards and volute springs of proper tension. The pump-pistons will be made of composition, with efficient metallic packing. The pump-rods of each pump will be made of phosphor bronze, 3 inches diameter, secured in the piston by a composition collar-nut accurately fitting the counter bore; the nut to be well sealed and locked. The rod will pass through a stuffing-box of ample depth for either the ordinary or metallic packing, and will be screwed into its cross-head and securely locked. The cross-head will be made of steel and will carry the brasses for cross-head end of connecting-rod, which will be secured by a cap and finished steel bolts and nuts, as shown in the drawings.

The cross-head will travel in cast-iron guides bolted at one end to air-pump chamber, and supported and fixed at the other end to a column resting on and secured to engine keelson. The cross-head gibs to be of composition and adjustable for wear.

The air-pump connecting-rods will be made of steel, with the pin at cross-head end worked from the solid forging; they will be 6 feet 8 inches long between centers, and will be finished with strap, gib, and key at the crank-pin ends. The brasses at this end will be bored 4 inches in diameter and faced 6 inches long, to fit the pin on engine-shaft. The cross-head brasses will be bored 3 inches diameter and 5¾ inches long, to fit the pin on cross-head end of rod.

### CIRCULATING-PUMPS.

The circulating-pumps, one in each engine compartment, will be of the centrifugal type, made of composition, and of approved design; each capable of discharging 10,000 gallons





of water per minute against a head of 19 feet of water, and will have induction and discharge openings of 15 inches diameter.

The pumps will be placed as shown on the drawings; connected on the induction side to the injection-valves and to the bilge, and on the delivery side to the condensers, with suitable valves for governing the direction of the current either through the condenser-tubes or overboard direct.

The induction and delivery pipes will be made of copper or brass, as may be required, of 15 inches diameter, with faced composition flanges of 3 inches width, riveted and brazed on. Each pump will be operated by a special engine connected directly with it; will take steam from both main and auxiliary steam-pipes direct, and exhaust into the auxiliary exhaust-main.

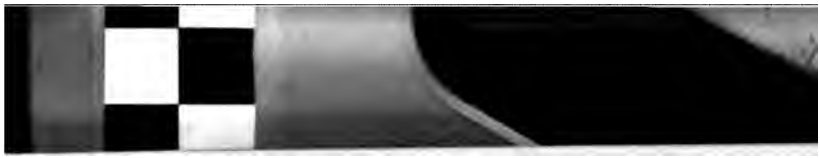
### INJECTION-VALVES.

There will be an injection-valve in each engine compartment, located as shown in the drawings. The chests, valves, seats, bonnets, glands, stems, and hand-wheels will be made of composition. Each valve will be faced with vulcanized rubber, and will cover an opening through the seat, of 15 inches diameter. Each chest will have an opening of 15¼ inches diameter, for attachment to ship's bottom, and will have two 15-inch diameter nozzles above the valve; one, for attachment to the circulating-pump; and the other, for attaching the bilge suction-pipe. A nozzle of 7 inches diameter of opening will be formed in the casting connecting the injection-valve chest with bottom of ship for attachment of sea suction-pipes of auxiliary pumps.

Composition strainers, perforated with $\frac{5}{8}$ inch holes, equivalent in area to twice the area of valve-opening, will cover the openings through the bottom of the ship.

### BILGE INJECTION.

A copper pipe of 15 inches internal diameter will connect the main injection valve-chest with the bilge-cistern in each





engine compartment. This pipe will have attached to it a composition non-return valve of 15 inches diameter of opening, which will be located in each compartment as shown in the drawings.

### OUTBOARD DELIVERY-VALVES.

The chests, bonnets, seats, valves, stems, and glands of the outboard delivery-valves will be made of composition. The valves will be fitted as checks to open by pressure from inside, and will be faced with vulcanized rubber, to cover openings through the seats, of 15 inches diameter. Each chest will have a nozzle of 6 inches diameter, outside of the main valve, for bilge discharge of auxiliary pumps. In the forward engine compartment, this nozzle, as well as the 7-inch nozzle on the injection valve-chest, will be closed by a composition plate securely bolted with bolts and nuts of Tobin's metal.

### SEA-VALVES.

The sea-valves, through the bottom of ship, in the fire-rooms, will be of the following sizes. They will be made entirely of composition; and those used for supply purposes to pumps will have composition gratings covering the openings through ship, of at least twice the area of valve openings.

One 5-inch valve in after fire-room of after compartment, between frames 57 and 58.

Two 6½-inch valves in forward fire-room of after compartment, between frames 48 and 49.

Two 5½-inch valves in after fire-room of forward compartment, between frames 42 and 43.

One 5-inch valve in forward fire-room of forward compartment, between frames 37 and 38.

One 6½ and one 5½ inch valve will be fitted with strainers; and will be connected to the induction side of auxiliary feed pumps, to the distilling-pump, and to the feed-pump of evaporators.

# ADDENDA.

## MACHINERY SPECIFICATIONS FOR U. S. S. NEWARK.

### (CRUISER NO. 1.)

#### AIR-DUCTS.

Each air-duct is to be so fitted that it can be easily closed from fire-room in case its blower is stopped.

#### ASH-HOISTS.

From each ash-hoist, on the upper deck, a permanent overhead rail, suitably supported, will lead to the nearest ash-chute on side of ship. Each of these will be fitted with a traveler of approved design, with all necessary appliances for carrying the ash-buckets. At the top of each ash-chute a dumping-hopper will be fitted, so arranged as to fold up out of the way when not in use. The ash-buckets are to be balanced dump-buckets with gear complete. All of the ash-hoisting and dumping-gear is to be such that the buckets will not have to be lifted by hand. A speaking-tube will lead from top of each ash-hoist to fire-room.

#### AUXILIARY STEAM-PIPES.

A steam-gauge in brass case, with 6-inch face, will be attached to the auxiliary steam-pipes in each engine-room and each boiler-compartment; also at windlass and steering-engine.

Branches from auxiliary steam and exhaust-pipes will lead to the engineer's workshop, for attachment to shop-engine, and be closed by blank flanges.

#### FURNACES.

Ash-pans of ¼-inch wrought-iron will be fitted in all furnace-flues, reaching from front to bridge-wall.

#### GRATE-BARS.

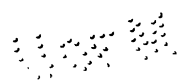
Cast-iron grate-bars will be fitted at the sides of furnaces to fit the corrugations.

#### INSTRUMENTS AND TOOLS.

A gauge of approved pattern will be fitted in each fire-room to show the excess of air-pressure over the pressure of the open atmosphere. A portable air-pressure gauge will also be supplied to each fire-room, with connections for attaching it to the furnaces, uptakes, and where directed, to measure the pressure as compared with the pressure in the fire-room. All of these gauges to indicate pressure in "inches of water."

A set of wrenches, fitting all nuts in fire-rooms, is to be supplied to each fire-room, placed in iron racks.

Fixed trammels or gauges are to be supplied for lining-up crank-shafts horizontally and vertically; marks for this purpose being made on brass plates let into pillow-block frames.



One 6½ and one 5½-inch valve will be used as blow-valves; and the two 5-inch valves will be used as bilge discharges from fire-room auxiliary-pumps.

### MAIN AND AUXILIARY FEED-PUMPS.

There will be four vertical, duplex pumps; two in each boiler compartment, located as shown in the drawings, one in each fire-room. Those in the after compartment will have water-cylinders of 6 inches diameter; those in the forward compartment 5¼ inches diameter; and all will have a stroke of 10 inches. The steam pistons will have an area twice that of their respective water pistons. The pump in forward fire-room of after boiler compartment and in after fire-room of forward boiler compartment, will be connected to feed-tanks, bottom of forward condenser, and boiler checks only; the others will be connected to draw from the feed-tanks, sea, bilges, and boilers; and to discharge into fire-main, boilers, and overboard; the connection to boilers being by a distinct set of pipes and checks independent of main feed system.

### TURNING-ENGINES AND BILGE-PUMP.

There will be a pair of engines having cylinders of 12 inches diameter and a stroke of 8 inches, located in after engine compartment, for turning the main engines in port; the shafting of these engines will carry worms, gearing into toothed wheels on propeller-shafting, and will have an approved disconnecting device. The attachment of the steam pistons to crank-shaft will be made by a yoke connection, and a prolongation of the piston-rods below the yoke will connect to the pistons of water-cylinders having a diameter of 8½ inches; these water cylinders will be connected on the receiving side to the sea-valve on main injection and to the bilge, and will deliver through a nozzle on outboard delivery-valve and into fire-main.

EVAPORATORS, DISTILLERS, AND THEIR PUMPS.

The distilling-apparatus will be located in the Engineer's work-shop on the berth-deck, and will consist of 2 evaporators and distillers of approved design, and of a capacity of 1,500 gallons of potable water each, per 24 hours.

The circulating pump will have a capacity equal to a No. BB Blake pump, and will take its steam from auxiliary steam-pipe. The pump for supplying the evaporators will have a capacity equal to a No. 0 Blake boiler feed-pump; will be connected by a branch pipe to the supply pipe of the circulating-pump, and will discharge into evaporators, through suitable check-valves.

The circulating-water, after passing through the distillers, will go forward through a 3-inch copper pipe for use in flushing the heads; and a 2-inch branch from this pipe, with suitable governing valves, will lead to officer's water-closets.

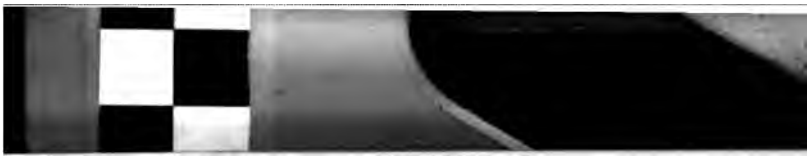
A 3-inch copper pipe fitted with suitable valves, will connect the discharge side of the circulating pump to the pipe leading forward to the heads, for use when, from any cause, the distillers are shut off.

The evaporators will be felted and lagged, and will be fitted (each) with a safety-valve, steam-gauge, glass water-gauge, salinometer pot, and blow-valve; the pipe from blow-valves to lead through the ship's side, or be connected to bottom blow-valve in after boiler compartment, as may be hereafter determined.

The distillers to be fitted with filters and with the pipes necessary for running the distilled water into the fresh water-tanks.

PUMP-CYLINDERS.

The water-cylinders of all steam-pumps will be made of composition, and will be fitted with relief-valves connecting the receiving with the delivery side of pump, and suitably loaded for the service required in each case. All pumps will have screw check-valves in suction and delivery-pipes close to





pump-chambers, and stop-valves on both steam and exhaust-pipes. All suction-pipes leading to bilge, excepting those from the circulating pumps, are to be fitted with Macomb's bilge-strainers. The steam-cylinders of all pumps, blowers, and other auxiliary machinery, will have their exhaust-passages connected to an exhaust-main, which will pass through engine and fire-rooms. This main will be connected to both main condensers and to the receivers of both engines; will likewise have a discharge into the atmosphere, and will be furnished with the necessary valves for governing the direction of the exhaust. Additionally, the main feed-pumps will be supplied with means of turning their exhaust-steam into their feed suction-pipes.

WORKING-PLATFORMS.

Working-platforms, of corrugated wrought iron not over ¼ of an inch in thickness, will be situated each side of bulkhead dividing engine-compartments, on a level about 2 feet above the center of crank-shafts, and will extend from about the center of the shaft to the throttle-valve. The gallery, which will extend around the engines on the same level as the working platform, will be made of wrought-iron rods ⅝ inch square, spaced not over ¾ of an inch apart. A footway about 2 feet wide, of corrugated wrought-iron not over ¼ of an inch in thickness will lead around the engines on a level with the top of engine keelsons. All handles, levers, and connections for operating the engines will be conveniently arranged on the working-platforms, with the counters, revolution-indicator, clock, steam and vacuum-gauges in plain view. Ladders will be provided as means of escape from engine-rooms when the water-tight doors are closed, and will be located as hereafter determined. The engine-room stairway for ordinary use will be accessible from the berth-deck, through a door in engine-room hatch bulkhead, and will have its landing on the working platform in the forward engine-compartment. A door under this stairway will communicate with after engine compartment, and suitable footways will be

arranged for access to the moving parts of the machinery, fitted, where required, with brass hand-rails and finished wrought-iron stanchions.

FEED WATER-TANKS.

A feed water-tank will be located in each engine-room, over the air-pump, as shown in the drawings. These will be made of wrought iron not over ¼ of an inch in thickness, and will each have a capacity of about 300 gallons. Each tank will be fitted as a filter, and be provided with a vapor-pipe, a float-valve for preventing access of air to feed-pumps, an overflow-pipe, and a glass-gauge.

A pipe of ample capacity will connect the tanks with each other, and will be furnished with a stop-valve for making or closing communication between the tanks. A supply-pipe will lead from these tanks to the main feed-pumps in fire-rooms.

LINE-SHAFTING.

The line-shaft of after-engine, connecting crank-shaft to thrust-section of shafting, will be about 8½ feet long; 13 inches in diameter excepting for a length of 9 inches, where it will be 14 inches diameter to receive the keys for securing the jacking-wheels, as shown in drawings; with coupling-discs 26 inches diameter and 3½ inches thick, forged on each end. The line-shafting of forward-engine will consist of two sections; one of which will be the duplicate of that above described, and the other will be about 20 feet 10 inches long; 13 inches diameter, with coupling-discs forged on each end, of the same diameter and thickness as above described. The different sections of line-shafting will be united to each other and to crank-shafts by six steel bolts 2½ inches diameter; and each pair of coupling-discs will be fitted with a cross-key of steel let into grooves slotted on their faces.

All sections of line-shafting will be made of steel; and will have a hole 4 inches in diameter, drilled through them axially. All shafting where it passes through water-tight bulkheads will be provided with stuffing-boxes.

### THRUST-SHAFTING.

The thrust sections of shafting, one for each engine, will be about 9 feet long, 13 inches diameter, with a coupling-disc forged on forward end 26 inches diameter and 3½ inches thick. The after end will be enlarged and made with a socket, bored 24 inches deep and tapering from 13 to 12 inches diameter, with suitable flanges for the coupling-bolts which take the thrust or pull when backing.

Each shaft will have 15 raised collars for taking the thrust, 1¼ inches thick, excepting the end collars, which will be 1½ inches thick, and 16½ inches outside diameter, with spaces of 1⅜ inches between them.

The shafts will be made of steel and will have a 4-inch hole drilled through them axially.

### PROPELLER-SHAFTING.

The propeller-shafting will be made of steel, in one length for each engine, and will have a diameter of 13 inches and a length of about 63 feet, the actual length to be taken from the ship.

Each inboard end of propeller-shafting will have a coupling-disc screwed on for uniting it to the thrust-section of shafting. This coupling-disc will have a diameter of 27¼ inches, a thickness of 4 inches, and will be secured to thrust-shaft by six steel bolts 2¼ inches diameter.

The shaft forward of this coupling-disc will be tapered to match the socket in after end of thrust-shafting, in which it will be secured by two feather keys. The after ends of shafts will be turned tapering to fit the propeller hubs, in which they will be secured by feather-keys of ample section, the backing-thrust being taken in each case by a closed composition nut on the end of shaft.

The propeller-shafting will be covered by a water-tight brass casing, extending from 3 inches abaft the coupling-discs to 3 inches within the hubs of the propellers. This casing

will be finished ½ an inch in thickness, except where it rests in bearings, where it will be ¾ of an inch thick.

All lengths of propeller-shafting will have a hole 4 inches in diameter drilled axially through them.

### PROPELLERS.

The propellers will be made of manganese bronze; they will have a diameter of about 15 feet, will be adjustable as regards pitch and will turn outward in forward motion.

### STERN-PIPES AND OUTSIDE-BEARINGS.

The stern-pipes and outside bearings will have composition bushings, divided in halves and fitted with lignumvitae staves, the bearings to be not less than 48 inches long, with proper flanges for securing them in position.

### STERN-PIPE STUFFING-BOXES.

The stern-pipe stuffing-boxes will be made of composition with a packing space of 1 inch in width and 7 inches in depth. The followers will be made of composition in two parts with a space of 1½ inches between them.

The stuffing-boxes will be bolted to the flanges of the stern-pipe, and the followers secured in place by bolts and nuts of Tobin's metal.

### THRUST-BLOCKS AND BEARINGS.

The thrust-blocks are to be of cast-iron, made for a circulation of water through them, and fitted with composition thrust-rings 1⅞ inches thick, arranged to match the rings and grooves of the shafts; the rings will be prevented from turning in their seats by chocks secured by the caps. The caps will be made with lugs locking into the blocks and will be fitted with ample oil and grease-cups with hinged covers and with tubes and wick-holders for each ring.

Four wrought-iron bolts of $1\frac{3}{4}$ inches diameter will secure the caps to the thrust-blocks.

The thrust-blocks will rest on foundations, built in the ship to which they will be secured in each case by 4 bolts $2\frac{1}{2}$ inches in diameter, and will be likewise fitted with keys for adjustment in any required direction.

### LINE-SHAFT PILLOW-BLOCKS AND BEARINGS.

There will be a line-shaft pillow-block, and bearing in each shaft-tunnel as shown in the drawings, secured in the same manner as the thrust-bearing blocks, and having a length of at least 18 inches. The blocks and caps will be made of cast-iron, andwill be provided with ample grease and oil-cups, fitted with tubes and wick-holders.

### SPRING-BEARING.

The length of line-shafting of forward-engine where it passes through after-engine compartment will be supported from the center engine keelson by a spring-bearing having a length of at least 15 inches.

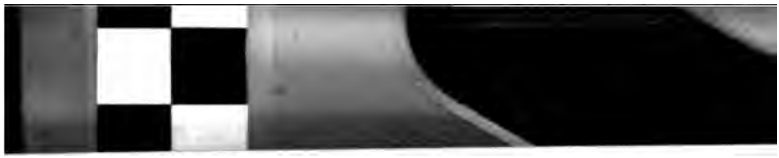
### JACKING OR TURNING WHEELS.

There will be a cast-iron wheel of about 44 inches diameter and 4 inches face, with teeth for meshing into the worms on shaft of the turning-engines, fitted to the line-shafting of each engine and located as shown in the drawings.

These wheels will be made in halves, securely bolted together and secured to their respective shafts by keys of ample section for taking the stress of the turning-engines.

### DISENGAGING-COUPLINGS AND FRICTION-WHEELS.

The coupling discs securing the line to the thrust-sections of shafting will be bolted together in each case by six accurately fitting tapered bolts of steel of at least $2\frac{1}{4}$ inches diameter at their smallest end.





Each after-disc will have keyed upon it the friction-wheel for holding the propeller when it is desirable to connect or disconnect the engines, and will be fitted with the requisite connections for rendering it complete in every respect.

### WATER-PIPES.

Seamless brass water-pipes 4 inches in diameter are to be fitted in each engine-room, and are to have two sea-connections each; two branches of not less than 1¼ inches diameter each, will extend to each main-shaft and crank-pin bearing; two branches of 1 inch diameter to each crosshead, and one branch 1 inch diameter to each eccentric. Also two 1-inch branches, to be secured into each main pillow-block, with holes leading through brasses to tops of journals.

A seamless brass water-pipe of two inches diameter will be fitted in each shaft-alley and will be supplied with water in each case by a 2-inch composition valve on the bottom or side of the ship.

Branches from these pipes will lead as follows: One 1-inch pipe for circulating water through each thrust pillow-block; two branches 1 inch diameter to each thrust-bearing, and one 1-inch branch to each line-shaft bearing.

All branch water-pipes will be fitted with cocks or valves for regulating the supply of water to bearings.

### JOURNAL-BOXES.

All journals or moving parts of iron or steel are to run in composition boxes; the crank-pin and crank-shaft boxes to be lined with an approved anti-friction metal.

### INDICATOR-FITTINGS AND MOTIONS.

Indicator-connections for each end of each steam-cylinder and air-pump are to be fitted as near as possible to the bore of their cylinders, and so located as to be easily accessible. The indicator motions are to be so designed as to give the indicator-barrel a motion coincident with that of the piston.

### REVOLUTION-INDICATORS.

Revolution-indicators showing on suitable dials the speed and direction of the engines are to be placed in each engine-room, and suitable dials for showing in which direction the engines are turning, are to be placed in such part of the ship, on deck, as may be required.

### OIL-CUPS.

Each crank-pin will be fitted with a centrifugal oiling device, as well as a telescopic or wiping arrangement, both to be of approved design. All crank-shaft bearings will have ample oil-cups with hinged covers, tubes, and wick-holders, and so arranged that the amount of oil passing down each tube to the journals can be seen and regulated.

All other joints or moving parts not otherwise referred to, and especially the cross-head slides and valve-gear, are to have finished brass automatic oiling-gear of approved design.

Each valve-chest is to have two properly finished brass globe or pump oil-cups with the necessary valves or cocks.

There will also be fitted to each main steam-pipe, close to the steam-chest, a Seibert sight-feed oil-cup of two quarts capacity, with ample condensing surface on its stand-pipe. All fixed bearings will have drip-cups cast on where possible; otherwise, they will be made of cast brass and properly fitted. All such cups will have drain-pipes and cocks of at least $\frac{1}{2}$ inch diameter, which can be used while the engines are in operation. All moving bearings to have drip-cups or pans of sheet brass where required.

### HOLES THROUGH SHIP.

All holes through the ship, in engine department, are to be covered with cocks or valves on the inside, and will be fitted with zinc protecting rings, if required.

### PUMP CONNECTIONS TO FIRE-MAIN.

The pumps in after engine compartment and in forward and after fire-rooms, will each have a discharge-pipe with straight-way stop-valve connecting it with the fire-main on berth-deck, and a branch from each discharge-pipe near the pump will be fitted with standard hose connection and straight-way stop-valve.

### EYE-BOLTS.

Wrought-iron bolts and traveler-bars will be located and secured wherever required for lifting different parts of the machinery, and particularly the covers of cylinders and valve-chests, air and circulating-pumps, condenser-bonnets, connecting rods, and caps of crank-shaft, line and thrust-shaft bearings.

### SECURING ENGINES IN SHIP.

The engines will be adjusted and lined upon the engine-keelsons by means of wooden wedges driven from both sides of the bearing-surfaces; and when accurately in line, the spaces around holding-down bolts between sole-plates and keelsons will be filled by accurately fitting wrought-iron horse-shoe washers, upon which the holding-down bolts will be set up and locked in place.

### STEERING-ENGINE.

A steering-engine of the Williamson type will be supplied, and fitted where shown on the plans. It should be of the latest type, to work by hand or steam power, and of sufficient power to put the rudder from amidships to hard over in 12 seconds when the vessel is going ahead at the rate of 18 knots per hour. The engine contractors will fit and secure the engine, supply the steering-wheels directly attached to it, make the steam and exhaust connections, and supply and fit the whole main shaft and sprocket-wheel; but all deck-wheels

and all rods and gear for actuating the valves from the deck, are to be fitted by the hull contractors, who will also cut all holes in the decks and bulkheads for securing the engine and running the shaft, &c. Where the shaft passes through bulkheads, brass stuffing-boxes will be fitted water-tight. All journals are to be in brass bearings, and fitted with self-feeding oil-cups.

### STEAM-WINDLASS AND CAPSTAN.

A steam-windlass of approved pattern, suitable for $2\frac{1}{8}$-inch chain, will be supplied and fitted. It will be located on the main deck, under the forecastle, where shown on the plans of the hull, and will have a capstan attachment on the deck above. Both capstan and windlass should work by either hand or steam-power. The steam-cylinders, which should be of sufficient size to raise both anchors at once at the rate of 6 fathoms per minute, with steam pressure of 30 pounds by gauge, must have reversing-gear, and be located upon the main deck. Steam and exhaust connections will be made, and all fittings, capstan bars, and spare parts supplied complete.

The contractors for the hull will make all holes in the decks for securing the windlass and capstan, and will stow the fittings, &c.

### DRAIN-PIPES.

All receptacles where condensed steam is likely to accumulate will be provided with drain-pipes and cocks of ample capacity, leading to automatic traps, which will discharge into feed tanks. Bye-pass pipes will be fitted to all traps, to allow a passage of water while overhauling traps.

Drain-pipes from safety-valves to be connected at least $\frac{1}{2}$ inch below the level of valve-seats.

### BOILERS AND ATTACHMENTS.

There are to be four double-ended boilers of 14 feet diameter and 17 feet 6 inches length over heads, and two single-

ended boilers 14 feet in diameter and 9 feet 3 inches length over heads, with return-tubes over the furnaces.

They are to be placed fore and aft in the vessel, and in two water-tight compartments; two double-ended and two single-ended boilers in the after compartment and two double-ended boilers in the forward compartment, with two fire-rooms in each compartment as shown in drawings.

The boilers are to carry a working-pressure of 100 pounds per square inch above the atmosphere.

There are to be two fixed smoke-pipes in a vertical plane over the keel, one for the boilers of each compartment, located as shown in the drawings.

The boilers are to be constructed of open hearth steel.

All plates are to be planed on their edges, thoroughly calked on the inside and out wherever accessible.

Butt-jointed seams are to be covered with straps. All rivet holes are to be either drilled to full size or to be punched $\frac{1}{8}$ inch small and reamed in place to proper size.

### GRATE-SURFACE.

There will be three furnaces in each single-ended and six in each double-ended boiler, making 30 in all.

Each furnace will have a grate $42\frac{1}{2}$ inches wide and 6 feet 6 inches long, 23 feet in area, making a total grate-surface of 690 square feet in the six boilers.

### FURNACES.

The furnaces are to be of the best steel, welded at joints and corrugated; they are to be $42\frac{1}{2}$ inches in diameter inside of corrugation and $\frac{7}{16}$ of an inch thick. They are to be single riveted at their junctions with front-heads and combustion-chambers.

### GRATE-BARS.

The grate-bars to be of wrought-iron, in one length, of approved pattern. They will be arranged to be shaken by

proper tools at front end; these tools to be furnished. The furnace fronts, bridge walls, and bearers to be properly fitted to support the bars.

### BRIDGES.

The bridge walls will be made of $\frac{1}{2}$-inch plate-iron bent to form and secured by angle-irons. Fire-brick will protect these plates from the action of the fire.

### SHELLS.

The shells are to be made of plates $\frac{7}{8}$ of an inch thick; the longitudinal joints to be double-strapped and treble-riveted each side of seams, the proportions of joints to be as directed. The circular joints to be single-strapped and double-riveted. The shells will depart from a circular form at each end on top, where they will be rounded to quadrants, the radius of which is 34 inches. The back end of the single-ended boilers at the bottom to be slanted as shown in the drawings.

### TUBE-SHEETS AND HEADS.

The back and front tube-sheets will each be drilled for 376 tubes. The distance between tube-sheets to be 6 feet $5\frac{5}{8}$ inches; the tubes will be spaced $3\frac{3}{4}$ inches, center to center, vertically and horizontally.

The back tube-sheets to be $\frac{5}{8}$ inch thick; the front tube-sheets and heads, and the backs of the single-ended boilers are to be $\frac{3}{4}$ inch thick.

Both heads will be curved to a radius of 34 inches at the top. They will be flanged inward at the boiler shells, and the front heads will be flanged outward at the furnaces. The heads are to be connected to the shell by double staggered-riveting, and to the furnace-flues by single-riveting. The lower parts of the back heads of the single-ended boilers are to be bent to the angle shown in the drawings. The pieces forming the heads to be butted and strapped, as shown in the drawings.

BACK CONNECTIONS AND STAY-BOLTS.

The back connections will be formed by plates inclined from each other in the double-ended boilers, and from the back head in the single-ended boilers. The plates at the sides and backs of the back connections to be $\frac{1}{2}$ inch thick. The connections will be stayed to the shells of the boilers and to each other in the double-ended boilers, and to the back heads in the single-ended boilers, by steel stay-bolts $1\frac{3}{8}$ inches least diameter, spaced 8 inches vertically and horizontally, screwed in to sheets and fitted with nuts. These stay-bolts will be carried as low as the form of the surfaces will permit, and below that point on the bottom of each connection will be riveted two stiffening-angles 2 inches by $2\frac{1}{4}$ inches.

Each connection will be supported as shown on drawings.

STAY-DOMES.

There will be stay-domes on tube-sheets of same thickness as tube-sheets. Those on the outer side of wing-furnaces will be hemispherical in form, and those between the wing-furnaces to be semi-cylindrical in one section and oval in the other, and secured to the front head by braces, as shown on drawings.

HEEL-PLATES.

Above the upper row of screw stay-bolts there will be double heel-braces of the same diameter or cross-section as the stay-bolts, as shown in drawings.

MAN-HOLES AND PLATES.

The upper man-hole tube opening into the steam space of each boiler will be made of cast-steel, and double-riveted to the boiler-shell; the outer portion of man-hole tube to be flanged outward, and provided with a cover properly fitted and secured by bolts passing through flange and cover. The man-hole to give a clear opening of 12 inches by 15 inches. There will be three man-holes above the furnaces in the front of each single-

ended boiler, and at both ends of each double-ended boiler; also, one man-hole in each head of the double-ended boilers in the space between the wing and center furnace and below their centers, these holes to be diagonally opposite to each other; in the single-ended boilers there will be two man-holes below the furnaces, one either side of the center furnace. These man-holes to be 12 inches by 15 inches in the clear, provided with stiffening-rings; those above the furnaces will have the stiffening-rings inside of the boilers, of rectangular section, and riveted to the boilers by rivets with counter-sunk heads on the inside of boilers; those below the furnaces will have the stiffening-rings on the outside, with an extension forming washers for the angle-braces attached to the shell, as shown in the drawings. The man-hole plates to be made of cast-steel, with proper bolts, nuts, and clamps. Suitable hand-holes and plates to be fitted at backs of single-ended boilers.

### FURNACE FRONTS.

The furnace fronts are to be made with a channel-iron frame, covered with wrought-iron plates $\frac{1}{4}$ inch thick on the inside and $\frac{3}{8}$ inch thick on the outside, both plates to be suitably perforated for air entry, if so directed.

### FURNACE DOORS.

The furnace doors to be of wrought iron $\frac{1}{4}$ inch thick, and flanged 1 inch deep; each to be fitted with a perforated wrought-iron inner-plate, and to be provided with wrought-iron hinges, catches, and air-regulators on the outside of door. On each side of the furnace door there will be a small opening to admit a slice-bar; this opening to have a hinged-cover over outer plate.

### ASH-PAN DOORS.

The ash-pan doors are to be of wrought iron $\frac{1}{8}$ inch thick, flanged 1 inch deep, and fitted and secured to place so as to thoroughly close the ash-pans. Suitable wrought-iron handles,

catches and hooks for handling and suspending them on the front of connection-doors when not in use, will be fitted.

### FRONT CONNECTIONS AND UPTAKES.

The front connections and uptakes will be made with double-shell of iron secured to channel iron frames $2\frac{1}{2}$ x $1\frac{1}{2}$ inches. The inner plate will be about 6 pounds per square foot, and the outer plate 4 pounds per square foot, and the space between the plates filled with an approved non-conducting material. The connections will have a cross-section not less than the cross-section through the tubes. The connections and uptakes will pass through the protective deck and connect with smoke-pipes.

The uptakes of all boilers to be so arranged as to keep the gases of each boiler separate up to the level of the armor-bars. Above this the gases of the single-ended boilers are to have separate compartments until they reach their own divisions of the smoke pipe.

### DAMPERS.

There is to be a damper for each boiler, above the armor-bars and resting on them when closed. They are to be made in two thicknesses of wrought-iron, not less than 4 pounds per square foot. The two parts to be separated by channel irons and thimbles, and secured by rivets. The dampers to be fitted as directed and to be worked from the fire-rooms by approved mechanism so that they may be held in any position.

### CONNECTION DOORS.

There will be a connection door fitted for each nest of tubes, provided with wrought-iron hinges, handles, and catches. They will be made with double shell, the outer plate $\frac{1}{4}$ inch thick, flanged 1 inch; and the inner plate $\frac{3}{16}$ inch, flanged 2 inches deep; the space in the doors to be filled by an approved non-conducting material.

A shield of iron $\frac{1}{8}$ inch thick will be secured to the outer shell at a distance of 1 inch from it, open at top and bottom, to allow a circulation of air.

SMOKE-PIPES.

There will be two smoke-pipes; one for the forward boilers having a cross area of 39 square feet, and one for the after group of boilers having an area of 58½ square feet. The after pipe is to be divided by partitions of iron No. 8 B. W. G., so as to form three compartments, one for the after double-ended boilers, and one each for the single-ended boilers; the cross section of these compartments to be in proportion to the grate surface of their boilers. The pipes will be flat-sided with semi-circular ends; the distance between the sides of the forward pipe being 4 feet, and of the after pipe 6 feet. The height of smoke-pipe above the grates of center furnaces to be 60 feet. The lower sheets of pipes are to be of wrought-iron plates No. 7 B. W. G., and the upper sheets No. 8 B. W. G. All joints are to be butted with straps on the outside.

The pipes are to be surrounded by jackets throughout their lengths, leaving an annular space of at least 3 inches. The jackets to be of wrought-iron $\frac{1}{8}$ inch thick, and to be covered by hoods with sufficient space for the escape of hot air. The jackets are also to be made with strapped butt-joints. The pipes are to be providod with stays, eyes and shackles, and are to be supported in such a manner as to relieve the uptakes of their weight. The pipes will be stayed inside in an approved manner. A pivoted cover will be fitted in the forward pipe, and one in the larger compartment of the after pipe. Light movable covers to be fitted in the smaller compartments of the after pipe. The covers to be as near as possible to the tops of pipes without showing above them when open. Drain-troughs to be fitted below the covers so as to catch all water passing them when closed, with drain-pipes leading where directed. Each pivoted cover to be worked by approved mechanism from deck. A permanent ladder, reaching to the top of each pipe, to be fitted as directed.

SADDLES.

Each double-ended boiler will rest in three, and each single-ended boiler in two saddles, which are to be built in and form part of the hull. The boilers are to be secured by double-angle irons riveted to boilers and saddles.

STEAM-DRUMS.

There will be three steam-drums, secured in the upper spandrels between the boilers, as shown in the drawings, and of about the following dimensions, viz:

One 3 feet diameter and 5 feet 2 inches long.

One 3 feet diameter and 12 feet 3 inches long.

One 3 feet 3 inches diameter and 9 feet long.

The shells of drums to be $\frac{3}{8}$ inch thick and the heads $\frac{1}{2}$ inch thick. Longitudinal seams to be double-strapped and double-riveted. Circumferential seams to be lapped and double-riveted. Heads to be braced by stay-rods or gussets, as directed, and have flanges for connecting steam-pipes and manhole plates, as shown in drawings.

DRY-PIPES.

Each boiler is to have a properly perforated, tinned-brass dry-pipe, closed at the internal end, of the same diameter as the steam-pipe with which it is connected. It is to be placed as high as possible, and extend nearly the length of the boiler. The upper surface is to be pierced with holes $\frac{3}{8}$ inch diameter, spaced equidistant, their aggregate area to be twice the cross-section of the pipe.

CIRCULATING-PLATES.

Circulating-plates of wrought iron will be fitted in the boilers as directed.

FELTING.

After the boilers are in place in the vessel, and have been tested under steam, their shells and fronts are to be covered

with asbestos quilting containing a layer of hair-felt 1¼ inches thick, or with other approved material, which will be protected by a galvanized iron covering, the joints of which will be lapped and bolted. The iron to be painted with two coats of brown zinc and oil.

### SAFETY-VALVES.

There will be two automatic spring safety-valves for each double-ended boiler, and one for each single-ended boiler; the valves to be adapted to a maximum pressure of 100 pounds per gauge and fitted with proper levers and approved mechanism for working from fire-rooms; valve-openings to be 6 inches in diameter.

The chests, valves, and stems are to be of composition. The seats of nickel, and raised at least ½ inch above bottom of chest.

The chests of valves for single-ended, and one of the valve-chests for the double-ended boilers, are to be bolted to a flange on boiler stop-valve; the other valve-chests of double-ended boilers to be bolted to the boiler-shells, as shown in the drawings. The chests will also be connected by copper pipes to the escape-pipes, one on either side of each smoke-pipe.

The escape-pipes will be of copper, and will extend to the top of smoke-pipes.

### SENTINEL-VALVES.

There will be a sentinel-valve of one-half square inch in area attached to each boiler where directed, the valve to be fitted with movable weight and notched lever, weighted to close tightly against a boiler pressure of 150 pounds per square inch.

### WATER-GAUGES.

Each boiler is to be provided with two composition water-gauges, each carrying a glass 16 inches in exposed length, and with outside pipe connections to top and bottom of boiler, not less than 1¼ inches inside diameter, with projection and recess at joints to prevent packing closing the opening.

There shall also be four gauge-cocks on each boiler, placed 4 inches apart, the lowest cock to be placed 4 inches below the highest heating surface of the boiler.

In addition to the above water-gauges, one composition water-gauge with 16-inch glass is to be placed on each double-ended boiler, on the end opposite to that having the gauge-cocks and two glass gauges. The bottoms of gauge-glasses to be 1 inch below the highest heating surface.

The glass gauges and the columns for the cocks will be independent of each other.

The cocks will be supplied with drip-pans and drain-pipes.

### STEAM-WHISTLE.

A composition steam-whistle, the bell of 6 inches diameter, is to be placed forward of the forward smoke-pipe, well above the level of the deck-awings, and connected to the main and auxiliary steam-pipes by a copper pipe having at its lower end a valve of appropriate size and kind, and a working-valve at its upper end.

### BOILER STOP-VALVES.

Each boiler is to have a composition stop-valve chamber placed on the boiler, as shown in drawings, or where directed, united with the boiler and dry-pipes by flanges of suitable size and thickness, and having, on its side or bottom, a nozzle under the valve, with suitable openings and flanges for safety-valve and auxiliary stop-valve chamber.

The stop-valves of single-ended boilers to have the auxiliary stop-valves connected, as shown in the drawings.

The flanges on nozzles on double-ended boilers for connecting auxiliary stop-valve to be closed by blank-flanges.

Safety-valves are to be connected with the main stop-valves of all boilers. The stop valve-chambers for the double-ended boilers are to have openings for steam, 10 inches diameter, and those for the single-ended boilers to have openings 7 inches diameter. Each valve to be fitted with a stem to turn inde-

with suitable valves at each end of pipe. One of the valves in each engine-room to be operated from the working platform.

CHECK-VALVES.

Each boiler is to have two sets of check-valves; one set for the main feed and one set for the auxiliary feed, each with separate pipes.

The valves are to be $2\frac{3}{4}$ inches in diameter, having outside screw-threads on their stems; chambers, valves, hand-wheels and stems are to be made of composition.

There will be two check-valves for the main feed system and two for the auxiliary feed system for each double-ended boiler; and one valve for the main and one for the auxiliary feed system for each single-ended boiler, to be connected to boilers as shown in the drawings or where directed.

All check-valves to have internal pipes, to direct the water downward after it enters the boilers.

HYDROKINETER.

There will be connected to each boiler a Weir's Hydrokineter or other approved appliance for circulating the water in the boiler while raising steam; proper connection being made to auxiliary steam-pipe.

BOILER DRAIN-COCKS.

There will be two drain-cocks of $1\frac{1}{2}$ inches diameter of opening fitted to each end of the double-ended boilers, and one to the after end of each single-ended boiler.

STEAM-PIPES.

The steam-pipes leading from stop-valves of double-ended boilers to drums will be $9\frac{3}{4}$ inches internal diameter, and from single-ended boilers to drum $6\frac{7}{8}$ inches internal diameter; pipes leading from drum of forward double-ended boilers to

the main steam-pipe in engine-room to be 13¾ inches internal diameter; pipes leading from drum of after double-ended boilers to be 13¾ inches, and from drum of single-ended boilers to be 9¾ inches. These pipes will be of these diameters to the junction of the pipes of the double-ended and single-ended-boiler drums; from this point to the steam-pipes in the engine-room, the pipe will be 16⅞ inches internal diameter.

The steam-pipes in the engine-rooms to be 15 inches internal diameter.

These pipes to lead as shown in the drawings and have a suitable stop-valve on each pipe in forward engine-room close to forward bulkhead, and a valve of approved design in pipe leading to after engine; also, a valve, not shown in drawing, to be placed in cross-pipe between starboard and port main steam-pipes; these valves to be operated from deck. T branches connecting these pipes with drums and with each other to be of suitable size, and have flanges of proper width and thickness.

These pipes are to be of copper, and the several sections are to be united to each other and to the drums, separators, and valve-chambers by composition flanges of suitable size and thickness, riveted on and properly brazed.

### PIPE-CLOTHING.

All main and auxiliary steam-pipes, exhaust-pipes where directed, the separators, and all steam-valves are to be clothed with an approved non-conducting material covered with canvas, in double thickness, well painted. The covering to be secured to bulkheads where pipes pass through them. The pipes also to be covered with black-walnut lagging with brass bands where directed.

### PIPES THROUGH BULKHEADS.

All pipes where they pass through water-tight bulkheads will be provided with stuffing boxes, or made tight in other approved manner.

BLOW-VALVES.

There will be one surface blow-valve and one bottom blow-valve for each boiler. The bottom blow-valves for the double-ended boilers to be 4 inches in diameter, and the surface blow-valves 2 inches in diameter; the bottom blow-valves for the single-ended boilers to be $2\frac{3}{4}$ inches, and the surface blow-valves $1\frac{1}{2}$ inches in diameter.

The bottom blow-valves to have internal pipes leading toward the bottom of boilers; the surface blow-valves to have pipes leading to the centers of boilers, with openings of pipes about one inch above the highest heating surface.

These valves are to be connected by suitable seamless copper pipes to the sea-valves.

SEPARATORS.

Two separators of approved kind are to be located in the after fire-room, as shown in drawings, one to be connected in the steam-pipe coming from the boilers in the forward compartment, and the other in the pipe from the boilers of the after compartment.

The separators to be of suitable dimensions and proportion to the area of steam-pipes connected with them. There will be a glass water-gauge at the bottom of each, 16 inches in exposed length of glass; and an automatic trap of approved pattern, with discharge to feed-tank or where directed.

FLOOR-PLATES.

The fire-rooms, with the passages leading to them, are to be floored with wrought-iron plates having corrugations on the upper surface, with proper ledges and drain holes.

They are to be not less than $\frac{1}{4}$ inch thick, and be made easily removable.

BLOWERS.

The fire-rooms are to be supplied with air by means of blowers, two for each fire-room. Each blower is to be driven

There will be an approved ash-hoisting engine for each fire-room, of suitable dimensions of cylinder to hoist 150 pounds with 20 pounds steam-pressure. They will be fitted with all necessary connections, including whip, and a suitable brake to control the drum.

### AIR-TIGHT FIRE-ROOMS.

Supplemental bulkheads and ceilings of galvanized iron No. 12 B. W. G. are to be fitted in the fire-rooms, where directed, for the purpose of reducing the capacity of the space to be put under air pressure.

All permanent and temporary joints and seams are to be made perfectly air-tight. The ceilings to be made movable beneath the hatches. The vertical portions to be provided with openings, where passage-ways are required, with suitable means for closing them.

### SALINOMETER POTS.

There is to be a salinometer pot of approved pattern connected with each boiler, fitted in an accessible position.

### BOILER TEST.

Before the boilers are placed in the vessel they will be tested under a pressure of 150 pounds by gauge. This pressure is to be obtained by the application of heat to water within the boilers, filling the boilers quite full. After a satisfactory test, the boilers are to be painted on the outside with two coats of brown zinc paint.

### FEED-PIPES.

The main feed-pipes for the double-ended boilers are to be made of seamless brass tubes, 5 inches internal diameter; and for the single-ended boilers they will be 3¾ inches internal diameter, and in sections not exceeding 12 feet in length.

The branches leading from the main pipes to the valves to be of copper or of brass, as may be directed, of the same thickness, and 2½ inches internal diameter.

All elbows, tees, and flanges, are to be of composition. The several sections are to have flanges riveted to their ends and brazed. All flanges to be united by bolts and nuts made of Tobin's metal.

Suitable provision for the expansion of these pipes will be supplied.

### TESTS OF MATERIAL.

All material used in the construction of the boilers, connecting-rods, crank-shafts, line, thrust, and propeller shafting will be tested in accordance with the "Instructions to Inspectors;" a copy of which is appended to these specifications.

### DUPLICATE PIECES.

All duplicate pieces are to be finished and fitted ready for use. They are to be as follows, viz:

One set of valves and springs for each steam-pump.

One seat, with guards and bolts complete for receiving valves and one for delivery valves of air-pump.

One-half set of follower-bolts and nuts for each steam piston, and one-half set for each air-pump piston.

One set of brasses for each crank-shaft journal.

One set of brasses for each crank-pin and cross-head journal.

One brass slipper for each cross-head.

One set of brasses for each thrust-bearing.

Two hundred condenser-tubes packed in boxes.

One hundred stay-tubes, threaded to fit threads in tube-sheets, and 300 plain boiler-tubes, swelled at one end and annealed. The ends of stay-tubes to be wrapped in canvas. All boiler-tubes to be securely stowed in racks, or as directed.

One hundred stay-tube nuts.

One spare basket for each Macomb's strainer.

One-eighth of a set of grate-bars.

All duplicate pieces not of brass, to be painted with three coats of white lead and oil, and well lashed in tarred canvas, with the name marked with black paint on the outside.

Brass pieces to be marked or stamped.

### OIL-TANKS, CANS, ETC.

An oil-tank of iron $\frac{1}{8}$ of an inch thick, to be divided by bulk-heads at right angles to each other, making four separate compartments with an aggregate capacity of 1,000 gallons, to be well secured in oil store-room, with facilities for filling from deck above.

Each compartment of tank to have a man-hole near the top, closed by a plate, and a locked cock for drawing oil.

Two copper oil-tanks each of 16 gallons capacity, and two copper oil-tanks each of 6 gallons capacity, with lids, drip-pans, and locked brass cock fitted to each tank, to be properly secured in each engine-room.

An iron tallow-tank of 100 pounds capacity, fitted with hinged cover, to be placed where directed.

### INSTRUMENTS, TOOLS, ETC.

Eight Thompson indicators of standard size, of the latest pattern made by the American Steam-Gauge Company, each to be fitted with two springs, one graduated to a scale of 40 pounds to the inch, and one to a scale of 16 pounds to the inch, with proper attachments of finished brass, are to be furnished ready fitted; also, an extra cock-attachment for each indicator.

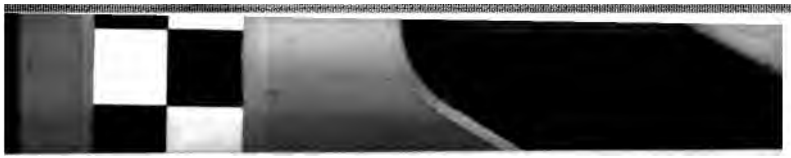
Each indicator stand-pipe is to be connected separately, and with but one end of each main cylinder, by a pipe 1 inch diameter, having a cock of equal area of opening.

Two sets of instruments with proper attachments, each instrument in its own case, which will be of brass, as follows, viz:

One Lane's improved spring steam-gauge.

One Lane's improved spring compound-gauge.

One Lane's improved spring vacuum-gauge.





One continuous counter, with positive motion to register from 1 to 1,000,000.

One eight-day clock, with second-hand.

Faces of all spring-gauges and clocks to be at least 8½ inches diameter.

One mercurial vacuum-gauge to be attached immediately to condenser.

The above list to be considered as one set.

There will be 10 Lane's improved steam-gauges, one for each single-ended boiler, and two for each double-ended boiler; with 8½-inch face, and graduated to 150 pounds.

Each gauge will be properly secured in fire-room and have an independent connection to its boiler.

Eight thermometers, one for each hot-well or feed-tank; one in each outboard delivery-pipe; one for each injection and one for each steam-pipe close to the engine, to be made permanent fixtures with their stems and bulbs protected by brass covers; also, two spare steam-thermometers, two spare water-thermometers, and one standardized-thermometer in suitable case.

An engine-room telegraph of approved pattern, with reply-gongs and the number of dials that may be found necessary, to be supplied and fitted for each pair of engines.

Approved devices will be supplied to put engine-rooms and fire-rooms in communication.

Two complete sets of fire-irons for each fire-room with suitable racks for stowing.

Lazy-bars for each furnace to be fitted in place.

One set of wrenches complete for each engine, to be fitted to all the nuts, finished and marked with size and placed in iron racks.

Wrenches for all nuts of bolts, 2 inches diameter and over, to be box wrenches, where such can be used.

One pair of taps on rod, for tapping front and back tube-sheets at one operation. This to be a duplicate of the tool used in originally tapping the sheets, and to be packed so as to be perfectly protected from injury.

SECURING CRANK-SHAFT AND CRANK-PIN BRASSES.

The top and bottom lips of crank-pin brasses will be secured to connecting-rod ends or caps, each by two 1¼-inch wrought-iron tap-bolts, tapped into lips of brasses near each end. The heads of these bolts to be recessed into rods or caps and secured by set screws. The lips of crank-shaft brasses will also be secured in an approved manner to prevent the brasses closing in when heated.

AUXILIARY EXHAUST TO ESCAPE-PIPES.

When the auxiliary exhaust-main is connected to the escape-pipes, it will have two stop-valves close together for each connection.

ASH-SPRINKLERS.

There will be on athwart-ship bulkheads of fire-rooms, opposite each boiler, about 4 feet from floor, a brass nozzle with universal joint, with valve and sea connections for wetting ashes. This to be of approved design, and to be secured alongside bulkhead when hot in use.

SCHEDULE OF COPPER AND BRASS PIPES.

*(Numbers refer to B. W. G.)*

Main steam-pipes, 16⅛ inches diameter, No. 3.
Main steam-pipes, 15 inches diameter, No. 4.
Main steam-pipes, 13¾ inches diameter, No. 4.
Main steam-pipes, 9¾ inches, diameter, No. 6.
Auxiliary steam-pipes, No. 10.
Air-pump discharge, No. 8.
Outboard delivery pipe, No. 8.
Circulating pump-suctions and discharge, No. 8.
Bilge-suction, (auxiliary,) No. 11.
Blow-pipes, No. 7.
Main exhaust-pipes, No. 5.
Main and auxiliary feed-pump delivery, No. 10.
Main and auxiliary feed-pump suction, No. 11.
Jet injection, No. 16.
Waste steam-pipes and auxiliary exhausts, No. 12.

Dry-pipes, No. 14.

All bends are to be made one gauge thicker than straight part of pipe.

All tee-pieces for brass pipes to be composition.

Expansion-joints are to be fitted to pipes wherever required.

MATERIALS AND WORKMANSHIP.

All materials used in the construction of the machinery are to be of the best quality. The iron castings to be made of the best pig-iron (not scrap); the brass castings to be made of new materials of best quality.

For all journal-boxes and guide-gibs the composition to be by weight: 6 parts copper, 1 part of tin, and ¼ of one part of zinc. Where Tobin's metal is specified, the composition to be 58.22 parts copper, 39.48 parts zinc, and 2.30 parts tin. For other brass work the composition is to be 88 parts copper, 10 parts of tin, and 2 parts of zinc.

All iron castings to be smooth and true to form, and before being painted to be well cleansed of sand and scale, and all fins and roughness removed. All boiler-plates to be thoroughly cleansed of oxide-of-iron scale.

Brass castings to be sound, smooth, and true.

No imperfect casting or unsound forging will be used if the imperfection affects the strength or, to a marked degree, its sightliness.

All steam, exhaust, and other pipes leading to and from steering and other engines, distillers, and pumps, are to be of sufficient size for their respective objects, and to have expansion-joints where directed.

All copper pipes, not seamless drawn, are to be brazed; and all copper pipes are to have composition flanges riveted on, calked on both sides and brazed. All pipes not otherwise specified to be of copper, and all pipes beneath floor-plates to be connected by forged bolts and nuts of Tobin's metal.

All nuts on rough castings to fit facings raised above the surface.

All pipes beneath floor-plates to be covered as directed, and care taken that they do not come in contact with the plates or frames of hull.

The work to be in every respect of the first quality and executed in a workmanlike and substantial manner.

All flanges to be faced and grooved.

All bolt-holes in permanently fixed parts to be reamed; and the body of the bolts to be finished to fit them snugly.

All threads on bolts to correspond to the navy standard.

All brasses to fit loosely between collars of shafting.

All cocks communicating with vacuum spaces to have bottom of shell cast in; and to have the plug packed by means of a stuffing-box and follower.

All nuts on moving parts and on pillow-blocks to be thoroughly secured with keepers, pins, or steel set-screws.

All brasses or journals to be properly channeled for the proper distribution of oil.

All flanges coupled together to be faced, and edges made fair with each other.

Metallic packing for stuffing-boxes to be such as may be approved.

The cylinder-casings, condensers, and all tubes and pipes are to be tested for tightness before being placed in the ship.

All engine work not finished, to be primed with two coats of brown zinc and oil, and when placed in position on board the vessel will be painted with two coats of paint of approved color.

The line-shafting is to be painted, when in place, with two coats of white-lead and oil; and the boiler fronts with two coats of lamp-black and oil. The smoke-pipes are to be thoroughly painted, both before and after erection on board the vessel.

All steam-pipes not lagged will be painted white; exhaust pipes, green; water supply pipes, red; and water discharge pipes, lead-color.

All materials and parts of the machinery shall be carefully weighed by the contractor when ready to go on board the vessel, and a record of the weights in detail furnished to the Inspector, certified to by him, and reported to the Bureau of Steam Engineering.

While the engines and boilers are being completed, steam shall be raised in the boilers whenever required to test the connections, the working of all parts of the main engines and

boilers, and all auxiliaries. All expense of such preliminary tests will be borne by the contractor.

Any portion of the work, whether partially or entirely completed, found defective, must be removed and satisfactorily replaced without extra charge.

All drawings necessary during the progress of the work must be prepared by and at the expense of the contractor.

Those which are merely developments of the official drawings and working plans in accordance with the specifications will be subject to the approval of the Engineer-in-Chief, or of the Inspector of Machinery, as may be directed, before the work is ordered or commenced. All plans involving changes or modifications of the original drawings must be approved by the Engineer-in-Chief. A complete set of drawings of the machinery, as fitted, must be furnished by the contractor, certified to by the Inspector of Machinery, and forwarded to the Bureau of Steam Engineering immediately upon completion of the work.

A suitable office and draughting-room, properly fitted and heated for the use of the Inspector of Machinery and his assistants, during the building of the machinery, is to be furnished by the contractor.

The contractors for the hull will supply the labor to fit the engine and boiler keelsons to the engines and boilers, and similarly for all auxiliaries.

All parts of machinery and boilers are to be secured in an approved manner to prevent displacement when the vessel is used for ramming.

The engines, boilers, uptakes, and smoke-pipes; all auxiliaries, their piping and connections; and all sea-valves, except the cutting of the holes for the same; and all parts described in these specifications and the official drawings, are to be fitted complete to the ship by the engine contractors; and any part of the machinery or any article pertaining thereto, which may have been inadvertently omitted from these specifications or from the official drawings, but which is necessary for the proper completion of the vessel, is to be supplied by the contractor, without extra charge.

# TESTS OF STEEL FOR CRUISERS.

## INSTRUCTIONS TO INSPECTORS.

The following rules are prescribed, in order to insure the fulfillment of the clause of the act of Congress of August 5, 1882: "Such vessels * * * to be constructed of steel of domestic manufacture, having as near as may be a tensile strength of not less than sixty thousand pounds to the square inch, and a ductility in eight inches of not less than twenty-five per centum."

I. All ship-plates, beams, angles, rivets, bolts, boiler-plates, and stays are to be inspected and tested at the place of manufacture by a naval inspector of material, and to be passed by him, subject to restrictions hereinafter mentioned, before acceptance by the shipbuilders, whether Government or private, for incorporation into said vessels.

II. Every plate, beam, and angle supplied for these vessels is to be clearly and indelibly stamped in two places and with two separate brands: 1st, with that of the maker, which shall distinguish the name of the manufactory or company; 2d, with the regulation brand of the naval inspector of material. The latter not to be stamped upon any of the above-mentioned material until it shall have passed an inspection for surface or other defects of manufacture, and the physical tests have been accepted by the Inspector and have been stamped with the maker's brand.

In case of small articles passed in bulk the above-mentioned brands shall be applied to the boxing or packing material of the objects.

No steel material to be received at the building-yards, for incorporation into vessels, except it bear, either upon its surface or that of its packings, both of these brands as evidence that it has passed the necessary government inspection.

III. The weight of all plates, beams, angles, &c., must be obtained by the Inspector of Material before delivery.

Plates of 12½ lbs. per square foot or less, and strips and bars of 6 lbs. per linear foot or less, may be accepted if the weights vary between 3 per cent. above and 5 per cent. below the specified weights.

All other plates and shapes may be accepted if the weights vary between the specified weights and 5 per cent. below them.

All plates and shapes not being within the limits here specified may be rejected.

TESTS.

All material except boiler-plates should be tested by heats, as follows:

A specimen ingot or bloom shall be selected and rolled into a plate or bar and test pieces cut therefrom; provided, always, that the test pieces shall have received no more working than that which the finished material from the heat would receive.

Four test pieces of the form shown in Fig. I, for plates (square or round, in condition as finished at the rolls, may be used for the tests of shapes), shall be made and tested for each heat.

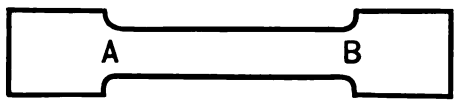



*Fig.* 1.

The length A B must be at least 8 inches of uniform cross-section, of which the area should not be less than $\frac{1}{2}$ nor more than $\frac{8}{10}$ of one square inch.

The reduction of width throughout the length A B should be just sufficient to prevent failure in the grips.

The test pieces must not be annealed unless the finished material is to be annealed.

Each test piece shall be submitted to a direct tensile stress, until it breaks, in a machine of approved character.

The initial stress to be 30,000 lbs. per square inch.

The first load to be kept in continuous action for one minute.

An observation to be made of the corresponding elongation measured upon the original length of 8 inches.

The stress then to be increased slowly until the principal elastic limit is determined, after which additional loads will be added at intervals of time nearly as possible equal, and separated by half a minute; the loads to produce an increase of stress of 5,000 lbs. per square inch of original section of the test piece until the stress is about 50,000 lbs. per square inch of original section, when increments of

These test pieces must not have their sheared sides rounded off; the only treatment permitted being the taking off the sharpness of the edges with a fine file.

Inspectors may require a cold bending test when considered necessary.

ANGLES, BEAMS, BULB-BARS, T-BARS, ETC.

V. Angle-bars are to be subject to the following additional tests: A piece cut from one bar in twenty to be opened out flat, while cold, under the hammer; a piece cut from another bar in the same lot shall be closed until the two sides touch while cold.

Bulb and T-bars are to be submitted to a closing test similar to that prescribed for angle-bars.

Bars submitted to these tests must show neither cracks, clifts, nor flaws.

RIVETS.

Each 1,000 lbs. of rivets from the same heat of metal shall constitute a lot, and be accompanied by two sample bars, each 18 inches long, for tensile test. These samples for tensile test shall be cut from the bars from which the lot of rivets is made, and be stamped with a number which shall also be placed on each box or package of that lot.

These samples to be subject to the same tensile test as that required for the plates.

The lot of rivets from which this sample bar does not fulfill the requirements of tensile strength and elongation required for plates, is to be rejected.

From each lot, six rivets are to be taken at random and submitted to the following tests, two rivets to be used for each test:

1. Two rivets to be flattened out cold, under the hammer, to the thickness of one-half the diameter without showing cracks or flaws.

2. The rivets to be flattened out hot, under the hammer, to a thickness one-third the diameter, without showing cracks or flaws.

3. Two rivets to be bent cold into the form of a hook with parallel sides, without showing cracks or flaws.

BOILER MATERIAL.

Two tensile test pieces shall be cut from each plate rolled for boilers, and one quenching test piece, which shall be tested as before described, except that in the tensile-test, the initial stress may be 25,000 lbs. to the square inch.

The limits of strength for all plates, braces, stays, angles, and T-bars shall be as follows:

The ductility in 8 inches must not be less than 25 per centum, and the ultimate tensile strength must not be less than 57,000 lbs. and not more than 63,000 lbs., and no single piece must show a less tensile strength than 57,000 lbs. to the square inch, except plates for flanging and those used in the construction of the furnaces, which will have an ultimate tensile strength of not less than 50,000 and of not more than 55,000 lbs., and a ductility in 8 inches of not less than 29 per cent.

No steel for boilers which is to be worked at a heat or to be annealed after working in the boiler-shops, shall be annealed at the works.

The acceptance of material under these tests will not relieve the contractor from the necessity of making good any material which fails in working or may be rejected by the Inspector.

## TEST OF HOLLOW STEEL SHAFTS.

1. Each length of rough-forged shaft should have a piece cut from it, at that end which was uppermost in the ingot, of sufficient size to allow the removal of specimens for tensile-test, parallel with the axis of the shaft, having a measured length of 4 inches between reference marks and of $\frac{1}{4}$ square inch sectional area when finished.

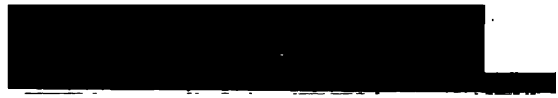
2. From the piece so removed, four test pieces shall be taken, two at circumference of finished diameter and two at $\frac{1}{4}$ radius from center. These pieces to be broken in a machine of approved character under the same conditions as prescribed for "Tests of Steel for Cruisers."

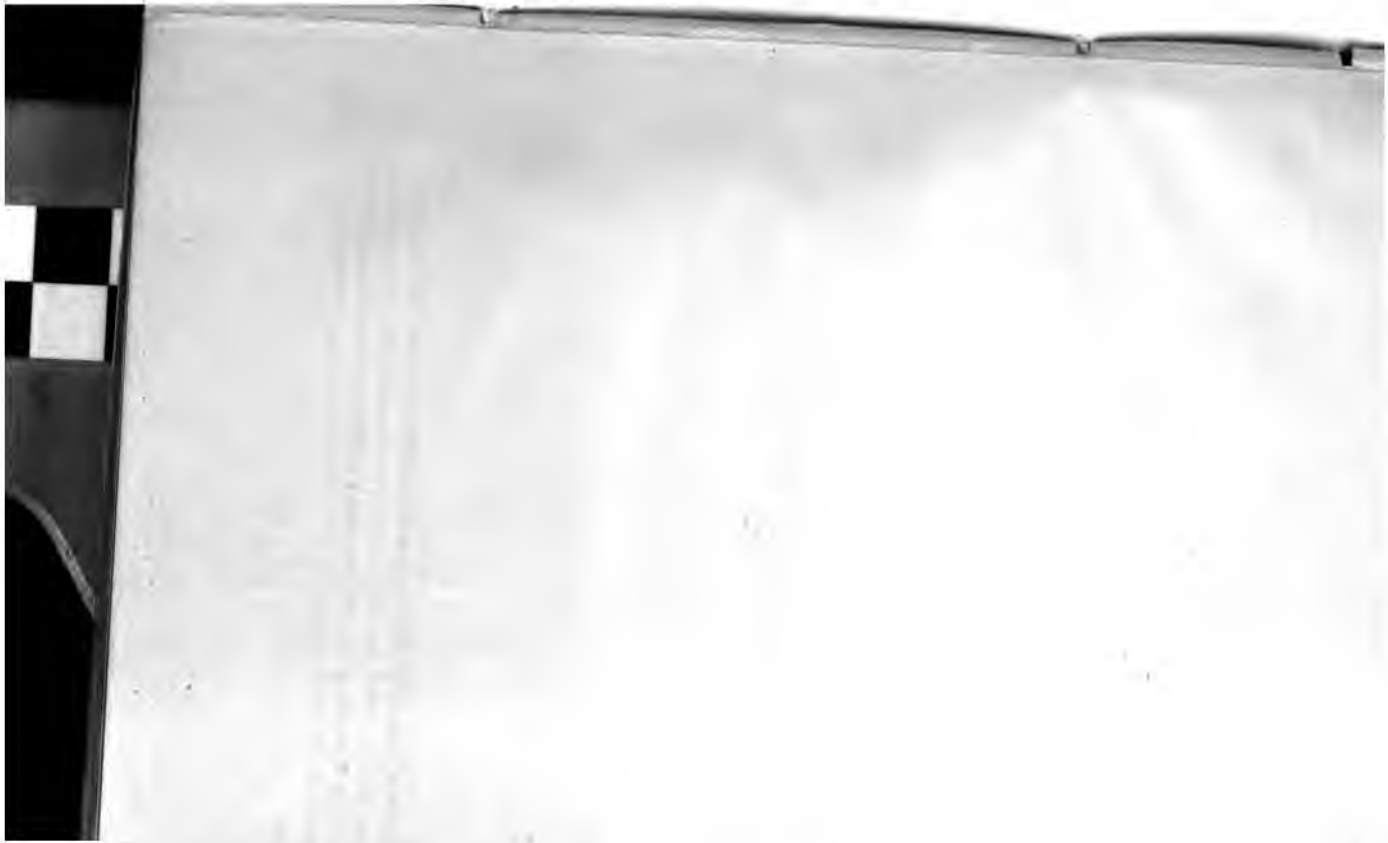
3. The ultimate tensile strength of the four pieces must be within the limits of 26 and 30 tons (of 2,240 lbs.) per square inch, and that of no single piece may fall below 25 tons. Pieces showing greater tensile strength than 30 tons will be accepted, provided the required ductility and other tests are satisfied.

The ductility of no piece at outer radius may be less than 20 per cent., and that of no piece at inner radius less than 16 per cent. in the measured length of 4 inches.

4. Bars $\frac{1}{4}$ inch thick, cut at the outer radius, must stand bending double to an inner diameter of $1\frac{1}{2}$ inches after common quenching in water, from a low cherry-red temperature.

5. Pieces cut from the rough-forged shaft for test may not be subjected to any subsequent treatment or process.



6. Inspectors of steel-shafting shall have full facilities to assure themselves of the general good quality of the metal and of a satisfactory method of manufacture, and may reject any piece considered to be defective in quality or fabrication without regard to the prescribed tests.

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